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JOURNAL OF CHEMICAL EDUCATION

for May, 1938

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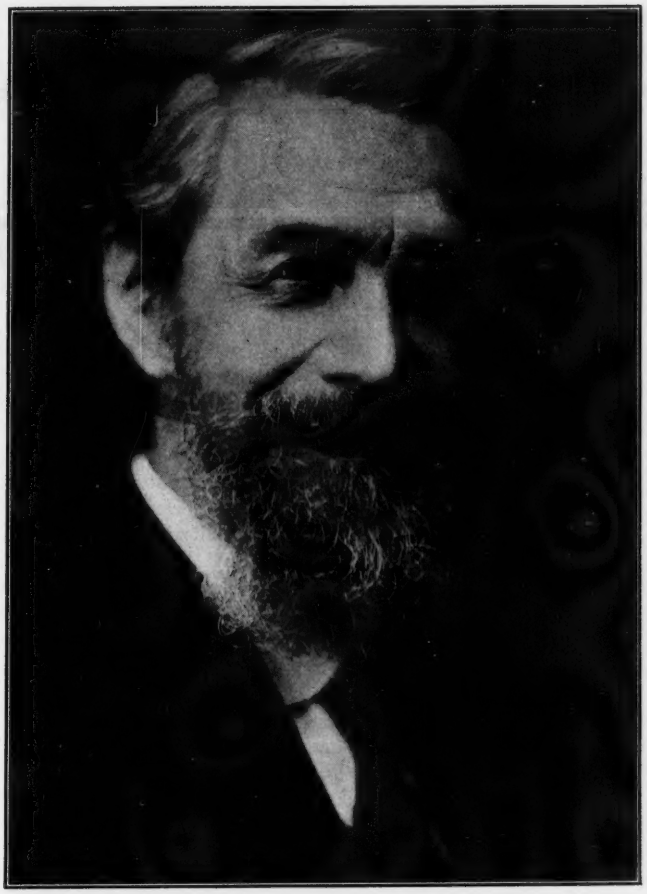

GEORGES URBAIN

A comparison of the list of the elements issued by the Société chimique de France with that put out by the Deutsche Chemische Gesellschaft reveals that Element 71 is called lutecium in France, cassiopeum in Germany, and similarly 72 is celtium and hafnium. The International Commission agrees with the French in the first case, with the Germans in the second. This regrettable and inconvenient situation, the offspring of priority disputes and chauvinism, is pointed out here because the subject of this sketch is the central figure in this controversy.*

Georges Urbain was born in Paris on April 12, 1872. After finishing his course as ingenieur chimiste at the École de Physique et de Chimie, he served (1895–98) as private assistant to Friedel, and was awarded (1899) his Docteur ès Sciences by the University of Paris for his thesis on the rare earths. In 1906 he became instructor, 1908 professor, and in 1928 director of the Institut de Chimie at the Sorbonne. He also is chief of the chemical division of the Institut de Biologie Physico-chemique.

From 1895 to 1912 he devoted his researches principally to the intricate problem of the rare earths. Tens of thousands of fractional crystallizations of suitable salts enabled him to group and then to isolate pure compounds of these closely related elements. He showed that the group consists of fifteen elements, and he was able to determine accurately the atomic weights of most of them. The crown of these masterly studies was his discovery (1907) of Element 71 which he named lutecium, in honor of his native city, whose ancient name was Lutetia. Urbain's claim to the discovery of 72, which he named celtium (1922), is not generally conceded. In 1912 he turned his researches, both theoretical and experimental, toward the study of complex compounds. Since 1925 his chief concern has been with molecular constitution, valence theories, and the rôle of the molecule in chemistry. In his book "Les disciplines d'une Science: La Chimie," he developed his theory of homeomerism (= similar properties), by whose aid it is possible, without hypotheses, to systematize the physico-chemical properties of compounds. He has written authoritative texts on spectroscopy, the chemistry of complex compounds, energetics of chemical reactions, coördination of atoms in the molecule and chemical symbolism.

For distinguished military service he was made Chevalier de la Legion d'Honneur in 1918 (Commandeur 1933); in 1921 he was elected to the Académie des Sciences. He has been president of the French Chemical Society, and of the Société de Chimie Physique, and of the Société de Minéralogie. He is an honorary member of the Chemical Society of London, corresponding member of the Academies of Brussels, Madrid, and U. S. S. R. He has served on the International Commission on Atomic Weights. This outstanding French chemist is also a competent musician and a capable artist.

(*Contributed by Ralph E. Oesper, University of Cincinnati*)

* The pertinent references concerning the work of Urbain, Auer von Welsbach, von Hevesy and Coster are given in M. E. Weeks's "The Discovery of the Elements."

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EDITOR'S OUTLOOK

THE TRAVELING PROFESSORSHIP—A SUGGESTION. The advantages of the visiting professorship and of the exchange professorships have long been recognized, and have been exploited, though perhaps not to the full extent of their potentialities, by the better-financed and better-staffed institutions. No university, however well-endowed, can hope to acquire a corner in outstanding professorial personnel in any well-established standpoint of the general welfare that any university should succeed in doing so. The principal advantages of such a monopoly are attained more economically, more efficiently, and more amicably by coöperative exchange and loan. In addition, the exchange or visiting lecturer enjoys the stimulus of new surroundings and contacts, and the benefit of interchange of ideas with his peers.

For various reasons, including fiscal, many small institutions (which, with all due respect to them, might reasonably be expected to have even more to gain from this system than their greater and more prosperous relatives) have been debarred from taking full advantage of it. A recent note in the *News Edition* of *Industrial and Engineering Chemistry* (April 10, 1938, p. 196) suggests an arrangement that might be capable of extensive development.

"E. Emmet Reid, emeritus professor of chemistry of The Johns Hopkins University, is acting as research consultant in chemistry to six southern institutions. . . . . Dr. Reid has made three trips to each of these institutions and in visiting the laboratories has allowed sufficient time to have individual conferences with each student who is working with organic problems. Some twenty students are now working under this principle. . . . . .

"It is too early to evaluate the results of this undertaking, but it has already proved of great value in the stimulation of research in the colleges concerned. The fact that Dr. Reid is making his years of experience available to these institutions and to their students is a contribution of real and lasting value."

One of the earliest of the successful modern efforts to secure by coöperative action benefits that the individual could not secure for himself created the mutual insurance societies and their successors. More recently small units in chemical and other industries have coöperated to set up research laboratories—an insurance against scientific and technological obsolescence. It may be that the time has come when small educational institutions should consider the feasibility of coöperative insurance against the overbidding of better-endowed competitors in the high-grade personnel markets. One form that such insurance might take is the establishment of traveling professorships.

Undoubtedly many small institutions are so situated that they could derive more benefit from the part-time services of an outstanding teacher of professorial rank than from those of an additional full-time instructor or assistant. The schools of medicine and law have often recognized this principle in securing the part-time services of active practitioners. The practice does not seem to have caught on to any extent, however, in our departments of chemistry.

It is true that many chemical professors of established reputation are now permanently rooted, and equally true that many men of promise lack the temperament that makes a life of permanent itinerancy attractive. There are doubtless, however, many excellent men who would undertake a year's interlude of travel as readily as they would a year's visiting lectureship.

If such a project were enthusiastically sponsored by a national scientific society or educational foundation, and if it received a bit of modest philanthropic backing at the outset, it might readily develop into the answer to some of our present prayers.

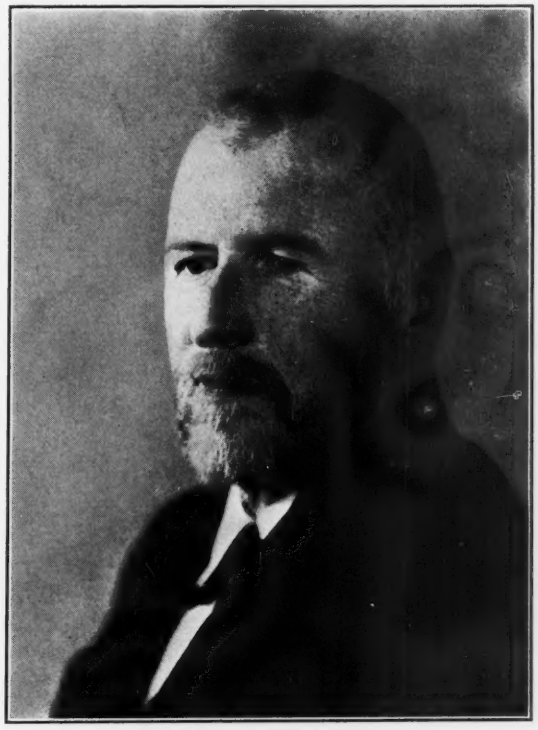
BORIS N. MENSHUTKIN'S CONTRIBUTIONS *to the* HISTORY *of* CHEMISTRY

TENNEY L. DAVIS

Massachusetts Institute of Technology, Cambridge, Massachusetts

THE present article started out to be a book review of Professor Menshutkin's "Work of M. V. Lomonosov in Physics and Chemistry"* (in Russian) (No. 48 below), dated 1936, a copy of which reached the reviewer in April, 1937. The book is definitive and deserves to be brought to the attention of all students of the history of chemistry—for it is written by the man who first called attention to the scientific writings of Lomonosov, edited them from manuscripts in the archives of the Russian Academy of Sciences, and by many publications has made Lomonosov known to the scientific world. It is the fruit of studies commenced in 1901 and continued during thirty years. It treats of the work of a great man, great in the history of Russian culture and great in the history of science. For the student of the history of chemistry who (like the writer) cannot read much Russian, it is something to know that the book exists, it is something to hope that the information contained in it will find its way into the English language.

No review of the book would be adequate unless it should make some mention of Menshutkin's other writings on Lomonosov, indicate what material on Lomonosov is available in English,† and tell something of the story of the way in which the facts about Lomonosov, gradually, and not yet sufficiently, have found their way to the knowledge of English-reading students. Menshutkin's first publication on Lomonosov was a book in Russian on "M. V. Lomonosov Considered as a Physical Chemist" (No. 2 below) published in 1904. This was followed in the next year by an article in German, "M. W. Lomonossow, der erste russische Chemiker und Physiker" (No. 4 below) published in *Annalen der Naturphilosophie*, and by a chapter on "M. W. Lomonossows Satz der Erhaltung der Energie und des Stoffes" (No. 8 below) in the Georg W. A. Kahlbaum Festschrift volume entitled "Beiträge aus der Geschichte der Chemie" in 1909. In 1910 No. 178 of Ostwald's *Klassiker der exakten Wissenschaften* appeared, "Physikalisch-chemische Abhandlungen M. W. Lomonossows, 1741–1752" (No. 9 below) excerpts from Lomonosov's writings translated into German from Russian and Latin and edited by B. N. Menshutkin and Max Speter, and accompanied by Menshutkin's notes. Through this book Alexander Smith became interested in Lomonosov, and his Presidential



BORIS N. MENSHUTKIN

* Titles of Russian books and articles and names of Russian journals are here cited in English translation. In the romanization of Russian names we have followed the rules laid down by the Russian Academy of Sciences; *cf.* J. CHEM. EDUC., **4**, 1079, *fn.* (1927). In cited titles the romanization of the original has been retained for the name of Lomonosov.

† Except for No. 178 of Ostwald's *Klassiker der exakten Wissenschaften* (No. 9 below), the only non-Russian *book* on Lomonosov with which we are acquainted is the interesting and attractive volume by the Marquis de Lur-Saluces, "Lomonossof, le Prodigieux Moujik," Emile-Paul Frères, Paris, 1933, which contains a general survey of his life and character and of his work as linguist, prosodist, lyric poet, dramatist, historian, geographer, astronomer, physicist, chemist, statesman, educator, and maker of mosaics.

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Address, delivered before the American Chemical Society at Washington, December 28, 1911, was based upon it and upon Menshutkin's earlier publications in German. This address, "An Early Physical Chemist, M. W. Lomonossoff," was printed in the *Journal of the American Chemical Society*, **34,** 109–19, February, 1912,* at the same time that a somewhat fuller article in English by Menshutkin on the "Bicentenary Anniversary of M. V. Lomonosoff's Birthday"

MICHAJL VASILIEVIČ LOMONOSOV (1711–1765)
(Oil painting, 1752)

(No. 15 below) appeared in the *Chemical News*, February 16 and 23, 1912. For fifteen years these two articles constituted the only sources in the English language of information about Lomonosov. Stillman in his "Story of Early Chemistry"† cited Alexander Smith's article and Ostwald's *Klassiker* No. 178, but overlooked Menshutkin's English paper. Later English-writing authors on the history of chemistry, even the most recent ones, have failed entirely to mention Lomonosov in their textbooks. Since 1912 the only authoritative new publication in English on Lomonosov has been an article by Menshutkin on "A Russian Physical Chemist of the Eighteenth Century" (No. 35 below) published with portrait in the JOURNAL OF CHEMICAL EDUCATION, **4,** 1079–87 (September, 1927).

A copy of Menshutkin's textbook of the history of chemistry, "Chemistry and the Ways of Its Development" (No. 66 below), in the Russian language, reached the reviewer in May, 1937. This also is a fine book, abundantly illustrated, containing portraits and other pictures which we have not seen published before, and, of course, containing more material on the contributions of the Russian chemists than is available elsewhere. But it is clear that this book cannot be discussed satisfactorily without reference to Menshutkin's other publications on the history of chemistry in Russia, to his writings on Mendeleev, N. A. Menshutkin, Zinin, Klaus, Lowitz, Hess, Petrov, Severgin, etc., and to his work in editing the "Proceedings of the Mendeleev Congress," 2 vols., Moscow and Leningrad, 1936, 1937, in which each paper is printed in the language of its author and in translation either into Russian or out of Russian as the case may be, and in which a number of extremely interesting pictures are reproduced. Then, in December, 1937, the reviewer received a copy of Menshutkin's illustrated "Biography of Michajl Vasilievič Lomonosov" (in Russian) (No. 59 below), the matured outcome of long thinking and of long study upon its subject, utterly authoritative, a book which will never have to be rewritten. A proper book review, obviously, can contain nothing less than an account of the author and an annotated list of his publications on the history of chemistry.

Boris Nikolayevič Menshutkin was born April 29, 1874, the son of Nikolaj Aleksandrovič Menshutkin who was Professor of Chemistry in the University of St. Petersburg from 1865 to 1902 and in the Polytechnic Institute up to the time of his death, January 23, 1907 (old style), three days after the death of Mendeleev. B. N. Menshutkin completed his studies at the University in 1895, and since that time has been teaching chemistry, first at the University as Assistant to his father (seven years, up to 1902), then as Chief Assistant in the Polytechnic Institute. In 1907, after the death of his father, he received the degree of *Magister Chemiae* from the University of Moscow, and was elected Extraordinary Professor of Analytical and Organic Chemistry in the Polytechnic Institute—Ordinary Professor from 1912—which post he occupied until the Polytechnic Institute was disbanded in 1930. In 1912 he received the degree of *Doctor Chemiae* from the University of Dorpat. From 1921 onward he was also Professor of Inorganic Chemistry at the Polytechnic Institute and Professor of Chemistry of the Forestry Technical Academy. From 1930 to 1934, after the dissolution of the Polytechnic Institute, he was Professor of General Chemistry at the

* It has been reprinted (with portrait) in L. A. Goldblatt's recent "Collateral readings in inorganic chemistry," D. Appleton-Century, New York and London, **1937,** pp. 17–22.

† STILLMAN, "The story of early chemistry," New York and London, **1924,** pp. 511–3.

Metallurgical Institute; and, since 1934, when that Institute was combined with several others into the Industrial Institute, he has been Professor of General Chemistry at the Industrial Institute. During the twenty-six years after the death of his father, he has lived with his mother who died in September, 1933, at the age of eighty-seven years.

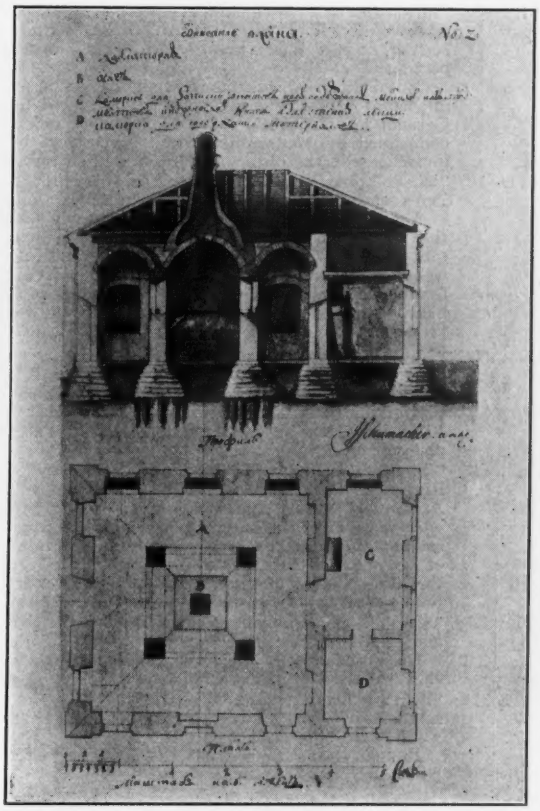
Professor Boris N. Menshutkin is well known for his many chemical researches, the records of which constitute about one-third of all of his publications. His textbooks, popular books, bibliographies, etc., make up, roughly, another third, and his publications on the history of chemistry bring the list to about two hundred and twenty items. His first published paper on an historical subject was written in 1894 while he was still a student. Since that time, for more than forty years, he has been working on the history of chemistry with the two-fold objective of collecting material for a complete history of chemistry in Russia, and of disseminating as widely as possible the historical knowledge of chemistry in general. The first purpose he has served by researches in archives such as those of the Academy of Sciences and of the University, and by a study of the lives and works of eminent chemists, of their printed investigations, and of their letters and manuscripts; the second by his courses in the history of chemistry, by popular lectures, by books, and by articles in popular periodicals. The appended bibliography is believed to be a complete list of all of Professor Menshutkin's printed publications on the history of chemistry. In addition, he has completed a biography of N. N. Zinin, which will be published in due course by the Academy of Sciences, and is at present engaged in the preparation of a history of the Chair of Chemistry of the Academy of Sciences and of the Academy's chemical laboratory during the eighteenth and nineteenth centuries. Long may he flourish! The list of material already published indicates the extraordinary wealth of information which he brought together for the use of students who can read Russian—for the benefit of the rest of us.

1895. (*1*) "Abridged History of the Discovery of Spectrum Analysis" (in Russian). *Messenger of Experimental Physics and Elementary Mathematics*, pp. 1–22.
Based on the original memoirs and treatises.

1904. (*2*) "M. V. Lomonosov Considered as a Physical Chemist" (in Russian). *Annals of the Polytechnic Institute of St. Petersburg*, 1904–1905, Vols. 1, 2, 3, 4. *Journal of the Russian Chemical Society*, Vol. 36. As a separate book, St. Petersburg, iv + 300 pages, with tables and illustrations.
This volume, embodying the results of Menshutkin's work on Lomonosov (1711–1765) during the years, 1901–1904, contains abridged translations of Latin dissertations copied from manuscripts in the Manuscript Library and in the Archives of the Academy of Sciences, as well as abridged reviews of Lomonosov's Russian memoirs, and covers all of Lomonosov's physico-chemical work as known at that time. One chapter is devoted to a description of Lomonosov's chemical laboratory, built in 1748, and contains the first published pictures of its plan and elevation. Lomonosov's lectures on physical chemistry, given at the Academic University, are here published for the first time. The importance of Lomonosov's work is discussed and its bearing upon the history of physics and chemistry.

1904. (*3*) "To the Memory of Aleksej Alekseevič Volkov" (in Russian). *Annals of the Polytechnic Institute of St. Petersburg*, Vol. 1, pp. 1–11, with portrait. *Journal of the Russian Chemical Society*, Vol. 36, pp. 350–9, with two tables of portraits.
Life and short description of the activity of Volkov (1863–1903) who was assistant to Professors D. I. Mendeleev, D. P. Konovalov, and N. A. Menshutkin at the University and at the Polytechnic Institute of St. Petersburg.

1905. (*4*) "M. W. Lomonossow, der erste russische Chemiker und Physiker" (in German). *Annalen der Naturphilosophie*, Vol. 4, pp. 204–25.



PLAN AND ELEVATION OF LOMONOSOV'S LABORATORY
Built at St. Petersburg in 1748, the first laboratory in the world for the regular instruction of university students in practical chemistry.

An abridged account of the life and work in physics and chemistry. First account of Lomonosov in a foreign periodical.

1908. (*5*) "M. V. Lomonosov as a Chemist" (in Russian). *Nature in School Life*, pp. 337–41.
Short popular account for teachers in gymnasia and other middle schools; describes Lomonosov's chemical investigations in historical perspective.

1908. (*6*) "Life and Activity of N. A. Menshutkin" (in Russian). St. Petersburg, viii + 374 pages, with portraits and illustrations.

Detailed biography of Professor B. N. Menshutkin's father (1842–1907); an account of his life at the University of St. Petersburg and at the Polytechnic Institute, of his scientific work and of his activities in the Russian Chemical Society, of which he was one of the founders, and in other institutions; complete bibliography and a list of all courses which he gave.

1908. (*7*) "Nikolaj Aleksandrovič Menshutkin" (in German). *Berichte der Deutschen Chemischen Gesellschaft*, Vol. 40, pp. 5087–98.

Abridged biography with portrait and description of scientific work.

1909. (*8*) "M. W. Lomonossows Satz der Erhaltung der Energie und des Stoffes" (in German). *Beiträge aus der Geschichte der Chemie*, Leipzig und Wien, pp. 463–7.

Discusses Lomonosov's "general natural law" in relation to the history of the law of the conservation of matter and of energy. Portrait.

1910. (*9*) "Physikalisch-chemische Abhandlungen M. W. Lomonossows, 1741–1752" (in German). *Ostwald's Klassiker der exakten Wissenschaften*, No. 178, 60 pages, portrait.

Contains textual excerpts from all of Lomonosov's important physico-chemical papers, translated into German by Menshutkin and Max Speter and accompanied by Menshutkin's notes discussing their importance in the history of physics and chemistry.

1911. (*10*) "M. V. Lomonosov and his Life" (in Russian). St. Petersburg, 160 pages, profusely illustrated.

Popular biography, in which Lomonosov's scientific work—which he always held to be more important than the literary—is given due prominence, as well as his artistic activity (mosaic pictures). Written for the Academy of Sciences on the occasion of the bicentenary of his birth. Eight editions were printed, 75,000 copies.

1911. (*11*) "M. V. Lomonosov as a Naturalist" (in Russian), 12 pages.

Address, delivered on the occasion of the celebration of the bicentenary of his birth, November 11, 1911, in which he is characterized as a natural philosopher.

1911. (*12*) "Corpuscular Philosophy of M. V. Lomonosov" (in Russian). *Collection of papers published by the Academy of Sciences*, pp. 151–6.

An account of the natural philosophy of Lomonosov and of his *magnum opus* which was to contain all of his work on chemistry and physics treated from the atomic point of view. His published dissertations were separate chapters of the projected work.

1911. (*13*) "M. V. Lomonosov and Phlogiston" (in Russian), *ibid.*, pp. 157–62.

Discussion of Lomonosov's relation to the dominant chemical theories of his time.

1911. (*14*) "Physico-chemical and Geographical Memoirs of Lomonosov" (in Russian). *Physico-chemical Papers of the Academy of Sciences*, pp. 1–103.

Russian translations from the Latin of selected papers on physics and chemistry.

1912. (*15*) "Bicentenary Anniversary of M. V. Lomonosoff's Birthday" (in English). *Chemical News*, Vol. 105, pp. 73–5, 85–7, February 16 and 23, 1912.

Short account of Lomonosov's life and scientific activity, written in answer to an enquiry from Sir William Crookes, Editor of *Chemical News*. First account in English based directly on the sources.

1912. (*16*) "Faddej Feliksovič Rotarski" (in Russian). *Annals of the Polytechnic Institute of St. Petersburg*, Vol. 18, pp. 1–3.

Obituary notice on the life and work of the author's assistant (1874–1912).

1913. (*17*) "M. V. Lomonosov" (in Russian). *Russian Biographical Dictionary*, 36 pages.

Biography and a complete review, with list, of all of Lomonosov's treatises; bibliography.

1913. (*18*) "First Synthesis of an Organic Substance" (in Russian). *Annals of the Polytechnic Institute of St. Petersburg*, Vol. 20, pp. 289–92.

Points out that Wöhler obtained synthetic urea in 1824, not in 1828, as commonly reported in the histories of chemistry, and that he obtained in 1824 synthetic oxalic acid from cyanogen.

1915. (*19*) "First Russian Scientist" (in Russian). *Knowledge for All*, pp. 1–36.

Popular account of the life and activities of Lomonosov; many tables and illustrations.

1916. (*20*) "Nikolaj Nikolaevič Zinin" (in Russian). *Russian Biographical Dictionary*, pp. 1–14.

Complete biography of Zinin (1812–1880); details of his chemical work and a list of all his scientific publications.

1920. (*21*) "Life and Scientific Activity of N. N. Zinin" (in Russian). Berlin, 122 pages with portrait.

Popular account.

1922 (*22*) "Notes on the First Binary Organic System Investigated by Means of Thermal Analysis" (in Russian). *Communications of Scientific and Engineering Work in the U.S.S.R.*, Vol. 6, p. 23.

Description and data given by Chevreuil in his treatise, "Recherches chimiques sur les corps gras d'origine animale," Paris, 1823, pp. 82–83, on the melting points of 101 mixtures of oleic and margaric acids containing from 0 to 100 per cent. of each acid.

1922. (*23*) "On Chemical Elements" (in Russian). *Engineering and Economic Messenger*, Vol. 2, pp. 2–7.

Short history of the conception of chemical element, including the development of the notion of isotopy as applied to non-radioactive elements.

1923. (*24*) "Physico-Chemical Works of Michajl Vasilievič Lomonosov" (in Russian), Classics of the Natural Sciences, Moscow, 123 pages with tables and figures.

The chief dissertations and papers of Lomonosov, given partly textually and partly in excerpts in Russian. A short biography and historical introduction are included.

1924. (*25*) "Centenary of Organic Synthesis" (in Russian). *Engineering and Economic Messenger*, Vol. 4, pp. 163–5.

1925. (*26*) "M. V. Lomonosov" (in Russian), Biographical Library, Moscow, 98 pages with portrait.

Second revised, corrected, and amplified edition of No. 10 above.

1925. (*27*) "First Russian Chemist" (in Russian). *Century of Chemistry*, No. 1, 4 pages with portrait.

Review of Lomonosov's chemical achievements.

1925. (*28*) "V. M. Severgin" (in Russian). *Century of Chemistry*, No. 2, 3 pages.

Short account of the life of Vasilij Mikhailovič Severgin (1765–1826), a member of the Academy of Sciences, of his work in mineralogy, and of his efforts to propagate the new knowledge. He was the first in Russia to adopt the new chemistry of Lavoisier.

1925. (*29*) "H. Hess" (in Russian). *Century of Chemistry*, No. 3, 2 pages.

Short account of the life and work of Professor and Academician H. Hess (1802–1850); discovery of his thermochemical laws; his work as Professor and author of "Fundamentals of Pure Chemistry" which was the standard textbook of chemistry from 1832 onward, for twenty years, in Russian higher schools.

1925. (*30*) "Halogens" (in Russian). *Engineering and Economic Messenger*, Vol. 5, pp. 1–8.

Chief points in the development of Russian chemical nomenclature, as evidenced in the names of the halogens and their compounds, correlated with the historical facts concerning chlorine, bromine, and iodine.

1926. (*31*) "A Russian Physical Chemist, V. V. Petrov" (in Russian). *Annals of the Institute of Physico-chemical Analysis*, Vol. 3, pp. 1–22.

Life and work of Professor and Academician, V. V. Petrov (1761–1834). Excerpts from his numerous books are given, showing how he cleared up the last "paradoxes" of Lavoisier. His electrical experiments, carried out with an enormous battery, are described (he was the first to obtain an arc flame between charcoal electrodes and the first to practice electrosmelting), and his investigations of the action of potassium on water in the absence of air.

1926. (*32*) "Contribution to the History of Russian Platinum"

(in Russian). *Annals of the Platinum Institute*, Vol. 5, pp. 201–6.

Documents relative to the discovery and the working of platinum in 1926. K. K. Klaus.

1926. (*33*) "The Periodic System of D. I. Mendeleev and Contemporary Chemistry" (in Russian). Classics of Natural Science, Moscow, 254 pages with portrait.

Brief biography; texts of memoirs relating to the periodic law and system; complete translation into Russian of the fundamental articles in Liebig's *Annalen der Chemie, Supplementband* **7**, 1872; an account of the discovery of the predicted elements; the bearing of Mendeleev's work on contemporary chemistry.

1926. (*34*) "Notes on the History of Chemistry" (in Russian). Moscow, 75 pages with portraits.

The contents are as follows: Introduction; I. Chemical Elements; II. Fundamental Chemical Laws; III. Atom and Molecule in Chemistry; IV. Chemical Formulas and Organic Compounds; V. Classification of Chemical Elements; VI. Relations between Physics and Chemistry.

1927. (*35*) "A Russian Physical Chemist of the Eighteenth Century" (in English). JOURNAL OF CHEMICAL EDUCATION, Vol. 4, pp. 1079–87, with portrait.

General account of the life and physico-chemical work of Lomonosov and of its historical significance.

1927. (*36*) "The Work of M. Berthelot in the History of Chemistry" (in Russian). *Symposia on the History of Sciences*, published by the Academy of Sciences, Vol. 3, pp. 132–56.

Address delivered at the Academy of Sciences at a meeting commemorating the centenary of the birth of Berthelot.

All of his works on the history of chemistry are reviewed and their important points discussed.

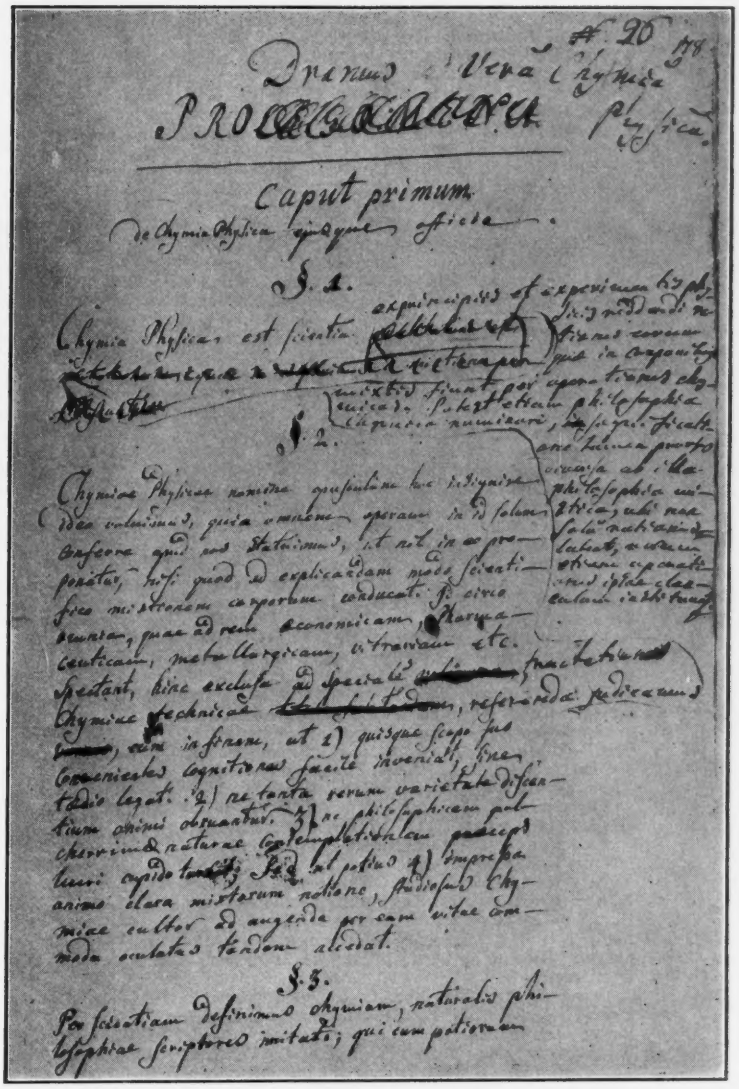
1928. (*37*) "Chemistry in the University of Moscow in the Early 1820's" (in Russian). *Annals of the Institute of Physico-chemical Analysis*, Vol. 4, pp. 1–22.

An account chiefly of the work of Professor F. F. Reuss, from 1804 onward, on the electrical conductivity of solutions and the phenomenon of electrophoresis which he discovered, of the total destruction of the University during the invasion of Napoleon, and of its reconstruction in 1813 and the following years; an account of the professors who worked there after its reconstruction.

1928. (*38*) "Karl Karlovič Klaus" (in Russian). *Annals of the Platinum Institute*, Vol. 6, pp. 1–10.

Short account of the life and work of K. K. Klaus (1796–1864), of his investigation of the platinum metals, and of the discovery of ruthenium.

1928. (*39*) "Life and Work of E. V. Biron" (in Russian). *Annals of the Forestry Institute*, Vol. 35, pp. 6–32.



FIRST PAGE OF LOMONOSOV'S MANUSCRIPT ON PHYSICAL CHEMISTRY

Chymia Physica est scientia ex principiis et experimentis physicis reddendi rationis eorum, quae in corporibus mixtis fiunt per operationes chymicas. Potest etiam philosophia chymica nominari, significatione tamen prorsus diversa ab illa philosophia mistica, ubi non solum rationes labent, verum etiam operationes ipsae clanculum instituuntur.

Physical Chemistry is the science which explains by means of the principles and experiments of physics the changes produced in compound bodies by chemical operations. It may also be called chemical philosophy, but it is quite different from that mystical philosophy wherein not only are no explanations given but the operations themselves are conducted in secret.

1930. (*40*) "Eugenij Vladislavovič Biron" (in Russian). *Journal of the Russian Chemical Society*, Vol. 62, pp. 1749–76, with portrait.

Biography and description of the activities of E. V. Biron (1873–1919), Professor of Physical Chemistry at the University of St. Petersburg and Professor of Chemistry at the Forestry Institute of St. Petersburg. Account of his chemical work and complete bibliography.

1932. (*41*) "Chief Stages in the Development of Chemistry

during the Last One Hundred and Fifty Years" (in Russian). Leningrad, 116 pages. Second revised edition, 1933, 121 pages. Third edition, 1934, 121 pages.

Contents: I. Chemistry before 1770; II. The Chemical Revolution of the End of the Eighteenth Century; III. Combinations of Chemical Elements; IV. The Atomic Hypothesis in Chemistry; V. Molecular Conceptions in Chemistry; VI. Triumph of the Molecular Doctrine; VII. Spectrum Analysis. VIII. The Periodic Law and Periodic System of the Elements; IX. New Chemical Elements; Valency; X. Physical Chemistry; Phase Rule; XI. Radioactivity and Radioactive Elements; XII. Structure of the Atom and of Matter; XIII. Atomic Number and Isotopes; XIV. What is a Chemical Element; Conclusion.

1934. (*42*) "Collected Works of M. V. Lomonosov." Published by the Academy of Sciences, Vol. VI, 438 + 131 pages, with many tables and figures. (Edited by Menshutkin with Introduction in Russian.)

Contains the original texts, in Latin and in Russian, of the following dissertations: I. Elementa Chymiae Mathematicae; II. De particulis physicis insensibilibus, corpora naturalia constituentibus, in quibus qualitatum particularium ratio sufficiens continetur; III. Meditationes de caloris et frigoris causa; IV. De tincturis metallorum; V. Tentamen theoriae de vi aeris elastica; VI. Supplementum ad theoriam de vi aeris elastica; VII. Dissertatio de actione menstruorum chymicorum in genere; VIII. Dissertatio de generatione et natura nitri; IX. Dromus ad veram Chymiam Physicam; X. Theoria electricitatis methodo mathematica concinnata; XI. De ratione quantitatis materiae et ponderis; XII. On the frost which occurred after warm weather on April 26, 1755; XIII. Investigation of the cause of aurora borealis; XIV. Anemometrum summam celeritatem cujusvis ventis et simul variationes directionum illius indicans; XV. Consilium de construendo Barometro Universali; XVI. Problema Physica de Tubo nyctoptico; XVII. Nova methodus observandi refractiones radiorum in omni genere pellucidorum corporum; XVIII. Conspectus potiorum theorematum, quibus scientiam naturalem locuplectare allaboravit Dn. Michael Lomonosow; XIX. Dissertations written as a student at Marburg; XX. Translation into Russian by Lomonosow of Chr. Wolff's "Abridged Experimental Physics."

1934. (*43*) *Ibid.*, Vol. VII, 591 pages with many tables and figures. (Edited by Menshutkin with Introduction in Russian.)

Texts of the following: I. De motu aeris in fodinis observato; II. First Fundamentals of Metallurgy; III. Tankar om Isbergens ursprung uti de Nordiska Hafven; IV. Short Description of Different Voyages on Boreal Seas showing the possibility of a passage through the Siberian Ocean to the East Indies; V. Instructions to Sea Commanding Officers going to seek a way to the East on the Boreal Siberian Ocean; VI. Chemical and Optical Notes; VII. Horizontoscope; VIII. Description of a Comet which appeared in the beginning of the year 1744.

1934. (*44*) "Early History of Mendeleev's Periodic Law" (in English). *Nature*, Vol. 133, p. 946.

Points out that the customary representation of the periodic system was given by Mendeleev in August, 1869, not in the year 1871, as stated in certain English publications.

1934. (*45*) "To the Memory of Pavel Pavlovič Fedotiev" (in Russian). *Nature* (Russian) and *Journal of Applied Chemistry*, pp. 1–6.

Obituary notice on the life and work of P. P. Fedotiev (1864–1934), Professor at the Polytechnic Institute of Leningrad. Full list of his publications and an account of his chief chemical activities.

1934. (*46*) "Fifty Years of Eutectics" (in Russian). *Metallurgist*, No. 7, pp. 1–8, with illustrations.

Historical review of the development of the investigation of alloys and solutions which enabled F. Guthrie in 1884 to introduce the conception of eutectics.

1935. (*47*) "Hundredth Anniversary of the Death of V. V. Petrov" (in Russian). *Nature* (Russian), No. 3, pp. 55–9.

Popular account of Petrov's life and work.

1936. (*48*) "Work of M. V. Lomonosov in Physics and Chemistry" (in Russian). Published by the Academy of Sciences, 537 pages, with numerous tables and figures.

Second edition, entirely recast and rewritten, of No. 2 above. Contains all the new material collected between 1904 and 1936 from a study of Lomonosov's manuscripts in the archives. Consists of sixteen chapters, as follows: I. Preliminary Data; Education Received by Lomonosov; II. Lomonosov as Adjunct and Professor of Chemistry at the Academy of Sciences; III. Atomic and Molecular Theories; IV. On Heat and Cold; V. Kinetic Theory of Air; VI. Electricity; VII. Ether; VIII. Mass and Cohesion; IX. First Chemical Dissertations; X. On Saltpeter; XI. Chemical Laboratory; XII. Laboratory Work; XIII. Physical Chemistry; XIV. Physico-Chemical Experiments; XV. Metallurgy and Genesis of Metals; XVI. Survey of the Work of Lomonosov as a Physical Chemist. All Latin dissertations are given in textual translations into Russian, and Russian memoirs are illustrated by quotations from the originals. Each dissertation is preceded by an historical introduction containing data on the time and circumstances of its composition, of its communication to the Academy, etc., and is followed by critical notes showing its relation to the work of predecessors and its bearing on the science of the present.

1936. (*49*) "M. V. Lomonosov as a Natural Philosopher" (in Russian). *Nature* (Russian), No. 12, pp. 129–37.

A popular account.

1936. (*50*) "Scientific Activity of M. V. Lomonosov" (in Russian). *Messenger of Knowledge*, No. 12, pp. 883–8.

A popular account.

1936. (*51*) "Lomonosov's Activity in Physics and Chemistry" (in Russian). Daily paper *Moscow Pravda*, November 21.

A popular account.

1936. (*52*) "Vasilij Vladimirovič Petrov and his Physico-Chemical Work" (in English). *Isis*, pp. 391–8.

Abridged account of his life and work.

1936. (*53*) "Early History of Russian Platinum" (in English). JOURNAL OF CHEMICAL EDUCATION, Vol. **11**, pp. 226–9, with illustrations.

Data on the discovery of platinum in the Ural mountains, on its mining, on its use for the minting of money; method of Sobolevskij for the working of platinum; concise history of Russian platinum up to the year 1845.

1936. (*54*) "Materials for the History of Thermal Analysis" (in Russian). *Annals of the Sector of Physico-Chemical Analysis*, Vol. 8, pp. 373–408, with many illustrations.

Contents: I. Temperature and its Measurement; II. Transformation of Liquid bodies into the Solid State and Vice Versa; III. Influence of the Admixture of a Second Substance on this Transformation; IV. Transformation of a Binary System from a Liquid to a Solid State; V. Thermal Analysis.

1936. (*55*) "Development of the Conception of Chemical Element" (in Russian). *Nature* (Russian), No. 2, pp. 117–29, with illustrations.

Concise historical investigation of the opinions of chemists on the nature of a chemical element, up to the present time.

1936. (*56*) "A. L. Lavoisier" (in Russian). *Messenger of Knowledge*, No. 3, pp. 195–201.

Popular account of the life and work of Lavoisier.

1937. (*57*) "M. V. Lomonosov's Work in Chemistry and Physics" (in Russian). *Academy of Sciences, Class of Social Sciences*, No. 1, pp. 243–7.

Address given in Moscow on November 21, 1936, at a joint meeting of the Academy of Sciences and the University of Moscow on the occasion of the two hundred and twenty-fifth anniversary of the birth of Lomonosov. General survey of the work of

Lomonosov in relation to the science of the present time.

1937. (*58*) "Life of M. V. Lomonosov" (in Russian). *Bulletin of the Academy of Sciences, Class of Social Sciences*, No. 1, pp. 35–147.

New biography based on contemporary data; full evaluation of Lomonosov's achievements in science, literature, and the arts, and as a statesman and educator.

1937. (*59*) "Biography of Michajl Vasilievič Lomonosov" (in Russian). Published by the Academy of Sciences, 238 pages, with many tables and illustrations.

A definitive biography, illustrated profusely.

1937. (*60*) "Lomonosov" (in Turkish). *Sovieto-Turkish Scientific Collected Papers*.

A popular account translated into Turkish.

1937. (*61*) "Tovij Egorovič Lowitz" (in Russian). *Messenger of Knowledge*, No. 4, pp. 48–51.

Short account of the life and work of the Russian chemist, Lowitz (1757–1804); his discovery of adsorption by charcoal, of supersaturated solutions, etc., introduction of microanalysis.

1937. (*62*) "V. M. Severgin" (in Russian). *Messenger of Knowledge*, No. 6, pp. 46–9, illustrated.

Cf. No. 28 above.

1937. (*63*) "Chemical Work of V. V. Petrov" (in Russian). Published by the Academy of Sciences, 25 pages.

Address given at a meeting of the Academy of Sciences and the Institute of History of Sciences and Industries in December, 1934. Petrov's chemical work is discussed fully, from its beginning up to his last investigation which dealt with the action of potassium on water in the absence of air.

1937. (*64*) "Chief Facts in the Development of the Periodic System of the Elements," 1868–1937 (in Russian). *Nature* (Russian), No. 3, pp. 116–26, with portrait.

Evolution of the periodic system during the last sixty years.

1937. (*65*) "The Periodic System of the Elements," 1907–1937 (in Russian). *Science and Engineering*, No. 2, pp. 5–9.

Development of the periodic system during the last thirty years.

1937. (*66*) "Chemistry and the Ways of its Development" (in Russian). Published by the Academy of Sciences, 352 pages, with 140 portraits and illustrations.

Contents: I. Origin of Chemistry; II. Greek Chemistry; III. Arab Alchemy; IV. Alchemy of Occidental Europe; V. Practical Chemistry during the Epoch of Renaissance; VI. New Ideas in Chemistry in the Eighteenth Century; VII. Theory of Phlogiston; VIII. Pending the Fall of the Theory of Phlogiston; IX. The Great Chemical Revolution; X. Chemical Elements during the First Half of the Nineteenth Century; XI. Reciprocal Combination of Chemical Elements; XII. Atomic Hypothesis in Chemistry; XIII. Origin of the Molecular Conception in Chemistry; XIV. Triumph of the Molecular Doctrine; XV. Weight of Atom and its Valence; XVI. Visible Spectrum of Chemical Elements; XVII. Chemical Elements and the Periodic Law; XVIII. New Chemical Elements after the year 1869; XIX. Radioactive Elements; XX. Structure of Atoms and their Mutual Cohesion; XXI. Isotopes; XXII. Modern Chemical Elements and their Systematics; XXIII. Interrelations between Physics and Chemistry; Conclusion.

1937. (*67*) "Historical Development of the Conception of Chemical Elements" (in English). JOURNAL OF CHEMICAL EDUCATION, Vol. 14, pp. 59–61.

Abridged translation of No. 55 above.

LAKES *as a* CHEMIST SEES THEM

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TO THE layman a lake is nothing other than a recreational area—a picturesque body of water, a place to go fishing, boating, or swimming in the summer and perhaps iceboating or skating in the winter. He little realizes the great activity that is continually occurring beneath the lake's surface, the extent and variety of the aquatic community, the dependence of the fish population upon the various micro and macro-zoölogical forms for food, or the correlation in turn between the abundance of these zoölogical forms and the chemical constituents of the lake water itself. For that matter, few scientists have a full appreciation of these relationships. However, lakes have been investigated scientifically for many years. That branch of science concerned with the study of lakes is known as limnology. In a broader sense limnology includes not only the study of lakes but also any inland waters, running or stationary. In this broader sense inland salt water lakes would also be included.

The first limnological work was entirely zoölogical in nature. Soon after the invention of the microscope minute organisms were discovered to be living in water. It was not until some time after, that the extent and variety of these organisms were fully realized. The term plankton was selected to designate all suspended, drifting, and microscopic life occurring in natural waters. At first it was thought that plankton was only present in marine waters, but this misconception was soon dispelled.

Although many European workers contributed to the

pioneering in limnology, Forel's work on the Swiss lakes was outstanding and inspired much work elsewhere in Europe. More recently important researches have been made in the United States and in other countries of the world. However, most of the thousands of lakes scattered throughout the United States as yet have had little or no limnological investigation. Of the work that has been done, that of Birge and Juday on the Wisconsin lakes has been particularly noteworthy because of the emphasis which they have attached to chemical analysis of the water made simultaneously with their biological studies. Because of their work and the influence which it has had on others, much has been learned of the chemical characteristics of lakes, the seasonal variations in chemical composition, and the correlation with the seasonal variation of plankton.

Much of the early exploration of the lakes has already been noted to have been zoölogical. This was made possible by the creation of the plankton net. The net as now used is made of very close meshed silk cloth and retains the plankton as the water passes through it. The simplest type of net is cone-shaped and is used to get qualitative samples by towing it horizontally through the water. A more complicated type is used in making quantitative vertical hauls. This type of net is so constructed that the mouth of the net may be closed whenever desired by sending a small weight down the line. The open net is sent down to any depth, pulled through a given stratum of water and then closed. On the way down the weighted net has its mouth toward the surface so no plankton gets within; it is only when it is pulled toward the surface that the plankton is collected. Since the area of the mouth is known, the volume of water passing through the net, when hauled upward, may be easily calculated and in this manner the quantity of plankton per unit volume of water may be obtained for any stratum of water between the surface and the bottom.

In a study of lakes, either chemical or biological, it is important to secure water temperatures at various levels. This is accurately done with the reversing minimum thermometer. When this instrument is reversed, unlike the ordinary thermometer, the reading does not change as the thermometer is hauled through the warmer surface water. Such thermometers have contributed much to our present knowledge of the thermal stratification of lake waters. F. Simony (1850) is commonly given credit for discovering thermal stratification. On the basis of thermal studies since his time lakes have been classified into three types—polar, temperate, and tropical. The surface temperature of a polar lake is never above 4°C. at any time of the year, while in a tropical lake it is never below 4°C. In temperate lakes it varies both above and below this temperature. Most of the North American lakes may be classed as temperate lakes. For that reason the discussion of the thermal stratification which is to follow is limited to the temperate class.

During the winter the temperate lakes have a temperature less than 4°C., the temperature of maximum density of water, and most of them are covered with ice. The temperature of the water below the ice is normally from 1° to 3°C. With the advent of the warm spring days the ice softens and breaks up, setting free the lake from its enforced period of hibernation. The surface water gradually is warmed to 4°C., all the while becoming denser. Naturally, just as soon as it becomes denser than the water below, an interchange ensues. In this manner the entire lake is finally set in circulation. The vigorous spring winds assist in the circulation by piling the surface water upon the lee shore. Since there is such a small differential at this time of year between the densities of the surface water and the bottom water, the hydrostatic pressure caused by the piling of the water on the lee shore causes that water to return to the windward shore along the bottom of the lake. The process of vertical circulation at this season of the year is known as the vernal or spring circulation.

Along in May or June the surface water has become warmer than 4°C. The density now is decreasing and vertical mixing is resisted; the effectiveness of the wind in circulating the water has been lessened. Wind currents can only include waters having a temperature differential no greater than two or three degrees. Moreover, by this time the strong winds of spring have abated. Consequently, only a layer of water five to ten meters in thickness continues in circulation. As a result heat can only be conveyed to the lower waters by absorption of solar energy or by means of conduction which in comparison with wind action is very ineffective. Eventually this process of warming the surface waters leads to a decided stratification within the lake, forming three layers of water—a warm surface layer, a cold bottom layer, and an intermediate transition zone. The surface layer is called the epilimnion, the transition zone the thermocline, and the bottom layer the hypolimnion. Since the latter two do not come in contact with the wind, they have little or no circulation. The thermocline is characterized by a big change in temperature with depth. It is defined as that layer of water in which there is a temperature change of at least one degree per meter of water. In a few lakes this change is as much as ten degrees per meter. The thermocline usually is from one to five meters in thickness, but occasionally is more. The temperature of the hypolimnion decreases slowly with depth as it absorbs but little heat through the thermocline. As a rule the temperature of the bottom water of deep lakes is just slightly more than 4°C. In lakes of great depth the temperature of the bottom water may be less than 4°C. Crater Lake, Oregon, with a depth of six hundred meters and a bottom temperature of 3.5°C. is a good example. Water is known to become less dense with a decrease of temperature below 4°C. so that the bottom water apparently is lighter than some of the overlying water with a slightly warmer temperature. Obviously, this is an impossibility. An explanation for this paradoxical situation is found in the effect of the hydrostatic pressure and compressibility of water under pressure upon the density of the bottom

waters. Because of this the final result is an increased density, in spite of the opposing thermal effect.

The depth of the thermocline within the lake is dependent upon the thickness of the epilimnion which varies seasonally. When the epilimnion is first apparent it may be only two to five meters in thickness. However, as a result of the penetration of solar heat the epilimnion keeps increasing in thickness. Accordingly, the thermocline must decline to a lower depth.

Along in August the lake attains its maximum temperature. From then on the days and nights become cooler and heat is given off by the lake to the overlying air. In so doing, the surface water becomes denser than the subsurface water and displaces it. Finally, the lake has cooled so much that the entire body of water is in vertical circulation. Assisted by wind action it continues until the temperature of the entire lake is four degrees. Then until the lake freezes the surface water becomes less dense on further cooling and thus resists and decreases further mixing. If the winter is sufficiently cold the lake freezes over for its period of hibernation. Hibernation is a term which does not necessarily denote complete inactivity, as there is always a certain amount of biological and chemical activity in the water below the ice.

It has been shown that there is a direct correlation between the temperature of the water and the air temperature and hours of sunshine. In spite of the yearly variations in weather, Birge and Juday have concluded that the temperature of a lake is remarkably constant from year to year, provided the comparison is made at corresponding seasons. It is true that in exceptional years the temperature of the epilimnion may vary by two or three degrees, but even then the thermocline and hypolimnion temperatures are almost identical with the results of normal years. The maximum mean temperature of the lake for the year and the minimum mean temperature may be calculated. The difference between the two, multiplied by the average depth of the lake in centimeters, gives what is called the annual heat budget of the lake. Since most lakes freeze during the winter, the winter temperature is usually taken as 4°C. On this basis it has been found that the average heat budgets of most eastern American lakes is about 35,000 to 40,000 gram calories per square centimeter of surface. European lakes have heat budgets about one-third less.

For a chemical study of a lake it is necessary to secure water samples from various depths. Many years ago this was quite a problem. Often weighted and stoppered bottles were lowered to the depth from which the water sample was desired and then filled by pulling out the stopper by a separate line. This was not an entirely satisfactory procedure because at great depths, as a result of the hydrostatic pressure, the bottle often broke, or the stopper could not be pulled. Sampling bottles have now been constructed that function very efficiently and cleverly. They are usually metal containers in the form of cylinders with stoppered ends. The ends are fastened open when the bottle is sent down, thus permitting the free passage of water through the bottle. At the proper depth the ends of the bottle are tripped and closed by the operator, sending a weight, called a messenger, down the line. The closed bottle is then brought to the surface without contamination by the surface waters. By this method samples may also be obtained for the analysis of dissolved gases.

All the gases of the atmosphere are probably present in lake waters, although only a few of the more common ones have been thought to be of enough importance to be investigated. The amount of each gas that is dissolved depends upon the normal physical factors, such as the partial pressure of the gas in the atmosphere, the solubility of the gas in the water, and the temperature of the water. The amount of carbon dioxide and oxygen depends not only upon these physical factors, but also upon various biological processes taking place within the lake, which include respiration by aquatic animals, in which oxygen is inhaled by the animals and carbon dioxide is exhaled, photosynthesis, in which carbon dioxide is used by the plants and oxygen evolved, and decomposition of the organic material within the lake and on the lake bottom. Oxygen is utilized in the decomposition processes, and the decomposition products are quite numerous. The most common ones are carbon dioxide, hydrogen, methane with usually small though variable amounts of hydrogen sulfide, sulfur dioxide, ammonia, and carbon monoxide. These latter products may be and sometimes are entirely lacking. Of all the dissolved gases, oxygen and carbon dioxide are of the greatest biological importance, and quite often the distributions of these gases are the only ones studied.

The carbon dioxide content of lake water is usually divided by limnologists into three groups for discussion, "free" carbon dioxide, "half-bound" carbon dioxide, and "fixed" carbon dioxide. The free carbon dioxide includes the dissolved carbon dioxide existing as carbonic acid, as well as the dissolved but uncombined carbon dioxide. By fixed carbon dioxide is meant that portion which would remain if the bicarbonate were decomposed to carbonate and the free carbon dioxide driven off. By half-bound carbon dioxide is meant that portion which has combined with the carbonate to yield bicarbonate. All these forms are, of course, in equilibria

$$CO_2 \text{ (air)} \leftrightarrows CO_2 \text{ (dissolved)} + H_2O \leftrightarrows H_2CO_3 \leftrightarrows H^+ + HCO_3^- \leftrightarrows H^+ + CO_3^=$$

The amounts of these ionic forms may be calculated when the hydrogen-ion concentration and the total carbon dioxide content of the water and the primary and secondary ionization constants for carbonic acid are known for the lake water medium.

The vertical distribution of these various forms of carbon dioxide is influenced by various biological processes and by the water circulation. During the turnover periods of the lake there is a thorough mixing of the water of the entire lake which obviously influences the distribution of all the various dissolved substances by making the lake homogeneous throughout. These periods of complete circulation have been aptly called

the breathing periods of the lake, since at these times oxygen is taken in by the water and carbon dioxide expelled.

During the spring months the days become warmer and thermal stratification of the water takes place and breathing ceases. At the same time there is an abundant plant growth with considerable photosynthesis. Most of the plant life is congregated in the epilimnion where the largest quantities of solar energy are available. Consequently, this stratum of water soon loses part or all of the free carbon dioxide with a corresponding gain in oxygen. As there is a definite relationship between the carbon dioxide and the hydrogen-ion content of the water, the pH of the water is an indication of the photosynthetic activity. Normally most lakes are near neutrality with a pH ranging from 6 to 7.5. When photosynthesis is at its height and the carbon dioxide is depleted the water becomes more alkaline and the pH increases to 7 or 8 or more.

In the region of the thermocline the oxygen usually decreases considerably and the carbon dioxide increases. The values are usually intermediate between those for the epilimnion and the hypolimnion. The largest carbon dioxide and the lowest oxygen concentrations are usually found in the hypolimnion. This is due to the large amount of decomposition taking place there, particularly during the summer. Dead plants and animals descend from the surface and decompose in the bottom waters. Because of the great amount of decomposition in the summer and because of the meager circulation in this water layer, this is sometimes called the period of stagnation. At first the increase in the carbon dioxide content and the decrease in the oxygen content are noted only in the layer of water immediately adjacent to the bottom mud; but during the course of the summer the thickness of this layer is gradually extended upward until it may include most or all of the hypolimnion.

In these bottom waters during the period of stagnation part or all of the oxygen may be entirely consumed. In water void of oxygen, hydrogen sulfide may exist in noticeable quantities. Apparently certain organic compounds containing sulfur may also be present, since the smell of hydrogen sulfide is sometimes detected quite definitely and yet none may be detected by the most sensitive chemical tests. It is also in these waters that the largest amounts of ammonia are also found. Normally, only a few hundredths of a P.P.M. (part per million, milligram per liter) or so of nitrogen are found as ammonia though occasionally as much as 0.5 P.P.M. may be present.

At the time of the fall turnover of the lake the lake breathes again. As the circulating water comes in contact with the atmosphere, oxygen is taken in again and carbon dioxide is evolved. The vigorous mixing effected by the wind distributes the dissolved gases homogeneously throughout the lake. This ceases when the temperature of the water is lowered below the temperature of maximum density for the water. Thus during the winter, particularly after the lake is covered with ice, very little mixing occurs. It is interesting to note the small part played by diffusion in the vertical distribution of oxygen and other chemical constituents. Calculations by Hüfer show that it would take 1,000,000 years for the bottom water of a 250 m. lake with a temperature of 10°C. to become saturated if it were completely void of oxygen to start with and had to acquire it entirely by diffusion.

Since the solubility of a gas is dependent upon the temperature of the water, the weight or volume of dissolved oxygen does not give a complete picture of the conditions in the water. For this reason the amount of oxygen is quite often expressed as the per cent. saturation—that is, the per cent. of the total amount of oxygen which the water could dissolve at that temperature under atmospheric pressure. Water in contact with the atmosphere might be expected to be just saturated—no more, no less; and this would be true, of course, if equilibrium were attained. However, conditions usually change so fast that equilibrium is seldom attained. The photosynthetic activity may be so great that the water may be supersaturated or the temperature may change so fast that the water may be either greater or less than one hundred per cent. saturated. Surface waters often are only eighty or ninety per cent. saturated, though values as high as two or three hundred per cent. have been noted occasionally in some lakes.

Aquatic plants, like terrestrial ones, need nutrient salts for growth. Though many elements are essential for plant growth, next to carbon dioxide, phosphate and nitrate are used in the largest quantities by aquatic plants. In addition silicate is a necessity for diatom growth as it is a major component in the shells of diatoms. These elements are furnished by the surrounding water in the form of nitrate, phosphate, and silicate. There is a nice correlation between the growth of plankton and the seasonal variation in the nitrate, phosphate, and silicate content of water. When an abundant growth of plankton occurs, the supply of these substances in the water is partially or entirely depleted. Certain investigators believe that the growth of plankton ceases when the supply of even one of these necessary nutrients is unavailable. However, plankton is known to grow in water containing no phosphate. Also, there must be other factors which can limit the growth of plankton; otherwise, just considering the supply of nutrients, it is difficult to explain: First, why the phytoplankton begins to grow more abundantly in the spring whereas an ample supply of food has been available throughout the winter months; second, why there are successive waves of plankton of different species following each other during the growing season; and third, the reason for the second pulse of phytoplankton in the fall months. The temperature of the water and the amount of sunshine are other factors that have been suggested as limiting the growth of plankton. Undoubtedly all these and possibly others must be considered in a study of the growth of plankton. In spite of the great amount of work that has been done in the

study of this problem, a completely satisfactory explanation as yet has not been advanced.

Phosphate, nitrate, and silicate though undoubtedly essential for plant growth occur only in small quantities in the water. It was only when rapid and sensitive colorimetric methods were made available that much was found out about the occurrence and distribution of these substances. Now it is known that phosphate is present only as a few thousandths of a P.P.M., nitrate a few hundredths or tenths of a P.P.M. and silicate a few tenths of a P.P.M. or more. Since all are used by plankton during growth the general seasonal distribution is much the same for all three. During the spring overturn the lake is homogeneous in respect to these three. When thermal stratification takes place and plankton growth increases, the quantities of each in the epilimnion are much reduced. Often phosphate is lacking throughout the entire summer; less often is nitrate depleted and still less often is silicate. During these months the plankton quickly reaches maturity, dies, and settles to the hypolimnion and finally to the bottom. Decomposition ensues and phosphate, silicate, and nitrate are regenerated in the bottom waters. This leads to concentration in the hypolimnion. It is not until the fall overturn of the lake that these nutrient substances are brought again to the surface waters and made available for plankton growth.

To get a complete picture of the potential food supply for the plankton it is not only necessary to know the amount of the phosphate and nitrate present but also the amount of the other forms of these elements present in the lake, that is, the organic phosphorus content and the other forms of nitrogen, including organic nitrogen, nitrite, and ammonia. Nitrite and ammonia may be present, though usually only in trace quantities, while organic nitrogen may be as much as a few P.P.M., but usually is only a few tenths of a P.P.M. The importance of organic nitrogen in the aquatic nitrogen cycle has been appreciated for some time, but it is only recently that organic phosphorus has been receiving similar attention. Even though there is less than a tenth of a P.P.M. of organic phosphorus, still this form is several times the quantity of soluble phosphate.

The organic material of a lake is composed of soluble and colloidal organic compounds and particulate matter. The latter is composed of plankton, living and dead, and detritus. It is definitely known that the aquatic animals feed upon the organic material, but just what kind of organic material has given rise to a vigorous controversy. It is known with certainty that the fish of a lake feed on the larger plankton forms. The controversy has centered around the source of food of these large plankton. Some think that they can utilize the dissolved organic material of the water directly; others are just as positive that this is an impossibility and that the larger forms feed on the smaller forms, such as bacteria and protozoa which, however, are capable of utilizing the dissolved material. At present those holding the latter view seem to have the better of the argument.

Not much has been discovered concerning the chemical compounds composing the dissolved organic material. Tryptophane, tyrosine, histidine, and cystine have been found to be present in Lake Mendota, Wisconsin, of course, all in very small quantities. Although it is difficult to detect and measure the individual organic constituents it is possible to get a rough measure of the whole.

A simple means is to determine the "oxygen consumed." This is done by measuring the amount of oxygen supplied by acid permanganate at 100°C. in oxidizing the organic material. It should be noted that reducing substances other than organic, if present in the water sample, are also oxidized and so frustrate the purpose of the determination, but—except under unusual conditions—such substances are not present. No information is gained from this determination concerning the specific compounds causing the reducing action so the information is only general in nature. Birge and Juday have concluded that the oxygen demand may be correlated with the brown coloration of most lakes and that on an average 1 mg. of organic carbon is present per liter for each mg. of oxygen consumed.

In conclusion, the author hopes that the reading of this article has stimulated a better appreciation of the place of chemistry in the field of limnology.

SUMMER COURSES IN CHEMICAL MICROSCOPY AND QUANTITATIVE MICROANALYSIS AT CORNELL

During the coming summer session at Cornell University, beginning July 5th and continuing six weeks, courses in chemical microscopy and in quantitative microanalysis will be offered.

The work in introductory chemical microscopy includes micrometry and quantitative studies, polarized light and the optical and physicochemical properties of crystals, lens systems and illumination, photomicrography, ultramicroscopy, and fiber studies. A course in microscopical inorganic qualitative analysis will also be given. Inquiries should be addressed to Professor C. W. Mason, Department of Chemistry, Cornell University, Ithaca, New York.

Quantitative microanalysis, with practice in typical methods for inorganic and organic materials, will be given by Professor M. L. Nichols, to whom inquiries should be addressed.

Persons not desiring university credit may arrange to cover, in a period of less than six weeks, portions of the above courses most suited to their needs, but enrolment is limited, and correspondence in advance of registration is advised.

A PRESENTATION *of the* FUNDAMENTALS *of* THERMODYNAMICS*

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STUDENTS of elementary thernodynamics often accept thermodynamic equations as arbitrary relationships, rather than as readily apparent applications of the fundamental laws. In the following presentation thermodynamic quantities are given names literally defining the quantity. Wherever possible, thermodynamic quantities are defined as properties of matter, rather than as properties of processes. Every equation and conclusion is developed completely from the definitions and the fundamental laws. The purpose of this presentation is to give a better understanding of the significance of thermodynamic quantities and equations.

The quantitative treatment of the relationships between different forms of energy is called thermodynamics. It is based on three statements called the laws of thermodynamics. They are:

First Law.—The first law states that energy cannot be created nor destroyed even though it be changed from one form to another. For an isolated system, this means that the sum of all the forms of energy is constant at all times.

Second Law.—The definition of temperature is of utmost importance to thermodynamics, but temperature is often used without being defined. Temperature is the intensity factor of heat and determines the direction of flow of heat. Energy can be transferred from one body to another in forms other than heat. When electricity is generated from water power, energy of position is converted into electrical energy, and we say that the water does work. In general, when a body gives up energy in any form other than heat, it is said to do work. When the body receives the energy, work is done on it.

The second law of thermodynamics may be stated as follows: it is impossible to construct any self-acting device, operating in a cycle, that will convert heat into work at constant temperature. Therefore, heat is *isothermally unavailable energy*. *Isothermally available energy* or *free energy* is energy that can be converted into work at constant temperature.

When a perfect gas expands at constant temperature, the gas may do work against the piston of an engine and absorb heat. The work is done at the expense of the internal available energy or work content of the gas. The heat absorbed, in keeping the temperature constant, goes into the gas and increases its isothermally unavailable energy.

In the kinetic study of energy, there may be a dynamic equilibrium between the different forms of energy. According to this picture, some of the heat absorbed by an expanding gas may be converted into work in accordance with the laws of chance. During the same time an equivalent amount of available energy is converted into unavailable energy. Thermodynamics deals with large numbers of molecules, in which case there is no net or observable change of unavailable energy into available energy.

Unavailable energy can be transferred from one body to another only as heat. Temperature is the intensity factor of heat. Therefore, temperature is the intensity factor of isothermally unavailable energy. The isothermally unavailable energy will be the product of the intensity factor, T, and a capacity factor, S. The *isothermally unavailable energy capacity*, S, is commonly called *entropy*.

Internal and External Energy of a Substance.—Let us transfer a volume, V, of liquid mercury from atmospheric pressure, P, to a vacuum, *i. e.*, where there is no environment pressure. If the atmosphere is not allowed to enter the space formerly occupied by the mercury, only the internal energy of the mercury is transferred into the vacuum. Then the free space possesses the external energy formerly associated with the mercury. If this free space were in the cylinder of an engine with a piston separating it from the atmosphere, one could let the piston be forced in by the atmosphere and obtain work, $P\Delta V$, or PV. Thus, any material of volume, V, under a constant environment pressure, P, has an external energy, PV.

It is important to distinguish between the internal and external energy of a substance. Internal energy is the energy actually existing within a substance. The external energy of a substance is the amount of work that may be obtained if the material is removed from its environment. The external energy may be due to gravity, electric field, magnetic field, or external pressure. Only the latter type will be considered in the following discussion. Theoretically, all the external or environmental energy of a substance can be converted into work; therefore, all the external energy

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of a substance is available energy. For any given portion of matter, one can write the following equation.

$$\underset{E}{\text{Internal energy}} + \underset{PV}{\text{external energy}} = \underset{H}{\text{total energy}} \quad (1)$$

Non-Isolated Systems.—For any system of matter, one may write the following equations.

$$\underset{F}{\text{Isothermally available energy}} + \underset{TS}{\text{isothermally unavailable energy}} = H \quad (2)$$

$$\underset{A}{\text{Isothermally available internal energy}} + \underset{TS}{\text{isothermally unavailable energy}} = \underset{E}{\text{internal energy}} \quad (3)$$

These equations define the symbols A, F, H, and E. The symbols of Lewis and Randall[1] are used throughout this paper. The total energy H is commonly called *heat content.*

If dq units of heat are absorbed and dw units of work are given up by a system, one may write the first law as follows:

$$dE = dq - dw \text{ or } \Delta E = q - w \quad (4)$$

where $q = \int_0^q dq$ and $w = \int_0^w dw$. Since $dw = PdV$ for any process involving only pressure and volume, the work, dw, involved in such a process is zero if the volume is constant. Therefore

$$dq_v = dE \text{ or } q_v = \Delta E \quad (5)$$

Differentiating equation (1) one has

$$dH = dE + PdV + VdP$$

Substituting dE from equation (4)

$$dH = dq - dw + PdV + VdP$$

But $dw = PdV$, and at constant pressure $dP = 0$, hence

$$dq_p = dH \text{ or } q_p = \Delta H \quad (6)$$

Heat Capacity.—Heat capacity is defined as the ratio of the heat absorbed per unit quantity of material to the rise in temperature for small increment in temperature.

$$C = \frac{dq}{dT} \quad (7)$$

If the volume is constant, $C_v = \frac{dq_v}{dT}$

If the pressure is constant $C_p = \frac{dq_p}{dT}$

Substituting from equations (5) and (6) one has

$$C_v = \left(\frac{\partial E}{\partial T}\right)_v \quad (8) \text{ and } C_p = \left(\frac{\partial H}{\partial T}\right)_p \quad (9)$$

Changes in Entropy or Isothermally Unavailable Energy Capacity.—It is apparent from the definition of the word unavailable that any process increasing the unavailable energy of an isolated system is an irreversible process. Any process decreasing the unavailable energy, TS, of an isolated system is impossible. The reverse process is impossible if it requires a decrease in TS. Therefore, for any reversible process in an isolated system,

$$d(TS) = 0 \quad (10)$$

Since unavailable energy can be transferred from one body to another only as heat, equation (10) is true for any reversible process in any thermally isolated system. Keeping the temperature constant, equation (10) becomes $TdS = 0$
or

$$dS = 0 \quad (11)$$

for every isothermally reversible process in a thermally isolated system. Any finite process, where the opposing forces differ by an infinitesimal amount, involves only an infinitesimal increase in the unavailable energy. Such a process is called a reversible process.

The transfer of heat at constant temperature is a reversible process, since an infinitesimal change in temperature reverses the direction of flow of heat. The reversible transfer of heat, at constant volume, or under constant environment pressure, involves no useful work. The only energy change is the transfer of unavailable energy. For an infinitesimal change under these conditions, the heat absorbed is equal to the change in TS or $dq = TdS$. Solving for the change in entropy

$$dS = \frac{dq_{rev.}}{T} \text{ or } \Delta S = \frac{q_{rev.}}{T} \quad (12)$$

When a substance is heated reversibly under constant pressure or volume, $dq = CdT$, C being the heat capacity. Substituting this in equation (12)

$$dS = \frac{CdT}{T} \text{ (constant } V \text{ or } P) \quad (13)$$

Entropy or isothermally unavailable energy capacity and heat capacity have the same dimensions and are usually given as calories per degree. The former is unavailable energy per degree of actual temperature, while the latter is the change in energy per degree rise in temperature.

Efficiency of a Reversible Heat Engine.—In a complete cycle, a reversible engine takes in q_2 units of heat at temperature T_2 and delivers q_1 units of heat to the condenser at temperature T_1, while doing work w. The engine gains entropy, q_2/T_2, at the higher temperature and loses entropy, q_1/T_1, at the lower temperature. The entropy change of the engine during a complete cycle is zero since it returns to its original state, where all of the properties of the engine are the same as at the beginning of the cycle. Therefore,

$$q_2/T_2 = q_1/T_1 \text{ or}$$

$$q_2 - q_1 = q_2 \frac{T_2 - T_1}{T_2}$$

[1] LEWIS AND RANDALL, "Thermodynamics and the free energy of chemical substances," McGraw-Hill Book Co., Inc., New York City, 1923.

Therefore, by the first law:

$$w = q_2 \frac{T_2 - T_1}{T_2} \tag{14}$$

Heat is unavailable energy only at constant temperature. When a condenser is available at a lower temperature, equation (14) gives the maximum amount of work that can be obtained. If the condenser were at the absolute zero, all of the heat energy would be available for doing work.

The temperature used here has been defined only as the intensity factor of heat. Since the same expression for the efficiency of a heat engine can be obtained by means of the Carnot cycle using the perfect gas-temperature scale, the thermodynamic temperature is proportional to the perfect gas-temperature. By taking one degree of the thermodynamic scale equal to one degree centigrade, the two temperature scales become identical.

The direct flow of heat from a body at a temperature T_2 to a body at a lower temperature T_1 is an irreversible process. The former loses entropy q/T_2 and the latter gains entropy q/T_1. The process involves an increase in entropy q/T_1-q/T_2. Every process that does not involve the irreversible flow of heat from a higher to a lower temperature can be resolved into isothermal parts. Therefore, an increase in entropy, of any thermally isolated system, is a criterion of irreversibility.

Changes in Internal Isothermally Available Energy or Work Content.—Any process requiring an increase in the internal available energy, A, is impossible at constant volume, *i. e.*, constant external energy. The reverse process is impossible if it involves an increase in A. A process is reversible when there is no change in A for either the forward or reverse process, *i. e.*,

$$dA = 0 \tag{15}$$

If a substance is allowed to expand reversibly and isothermally in an engine, the work done by the gas is equal to the decrease in the internal isothermally available energy, or

$$dA = -PdV \tag{16}$$

Under constant atmospheric pressure, the work done on the engine is less than the work done by the gas. The difference is the amount of work done in lifting the atmosphere to make room for the increased volume.

If an electro-chemical cell is allowed to operate reversibly in a constant volume bomb, the electrical work is done at the expense of the isothermally available internal energy and

$$dw = dA \text{ (constant } V \text{ and } T) \tag{17}$$

Changes in Total Isothermally Available Energy or Free Energy.—Any isothermal reversible process, occurring at constant pressure, can do useful work only at the expense of the total available energy and

$$dw = -dF \text{ (constant } T \text{ and } P) \tag{18}$$

Any isothermal and constant pressure process, involving no useful work on the system, is impossible if the total available energy increases. The reverse process is impossible if it requires an increase in available energy. The process is reversible when neither the forward nor the reverse reaction involves any change in the available energy, *i. e.*,

$$dF = 0 \text{ (constant } T \text{ and } P) \tag{19}$$

Combining equation (1), (2), and (3) gives

$$F = A + PV \text{ or } dF = dA + PdV + VdP \text{ (constant } T) \tag{20}$$

Substituting dA from the equation (16)

$$dF = -PdV + PdV + VdP \text{ or}$$

$$dF = VdP \text{ (constant } T) \tag{21}$$

When the pressure on one liter of solid iron is increased from one to two atmospheres, the free energy change, $V\Delta P$, is one liter atmosphere. The free energy change has the dimensions of work. Since the volume is constant, work is not done on the iron. The free energy change, VdP, is not work. The term, VdP, indicates a greater capacity for doing work, if the substance were permitted to contract under a higher pressure. A substance has more available energy under a higher environment pressure, the increase being in the external available energy. It is only under constant temperature and pressure that the free energy change is equal to the work done. When an electrochemical cell operates reversibly under constant temperature and pressure, the work done is equal to the free energy change, ΔF.

The Gibbs-Helmholtz Equation.—Differentiating the equation $F + TS = H$ (2) at constant pressure

$$\left(\frac{\partial F}{\partial T}\right)_p + T\left(\frac{\partial S}{\partial T}\right)_p + S = \left(\frac{\partial H}{\partial T}\right)_p \tag{22}$$

The second and last terms are both equal to C_p by the equations (9) and (13). They cancel out leaving

$$\left(\frac{\partial F}{\partial T}\right)_p = -S$$

Substituting $-S$ from equation (2) gives

$$\left(\frac{\partial F}{\partial T}\right)_p = \frac{F - H}{T}$$

Since F and H are additive properties, one may also write

$$\left(\frac{\partial \Delta F}{\partial T}\right)_p = \frac{\Delta F - \Delta H}{T} = -\Delta S \tag{23}$$

ΔF and ΔH are, respectively, the free energy change and the heat of reaction, at constant temperature and pressure. The heat of reaction can be calculated from this equation if ΔF and its temperature coefficient are known.

Chemical Equilibrium.—A chemical reaction, proceeding freely under equilibrium conditions, is a reversible process and does not involve any useful work. Equation (11), $dS = 0$, is a criterion of chemical equilibrium when q is zero. When the volume and

temperature are constant, equation (15), $dA = 0$, is a test of chemical equilibrium. When the pressure and temperature are constant, equation (19), $dF = 0$, is the test of chemical equilibrium. The last test for equilibrium is far the most important, since we live under conditions approximating constant pressure and temperature. A reaction mixture in a closed bomb is at equilibrium when $\Delta A = 0$ for the reaction. The first test, when $q = 0$, is only useful for very fast reactions, where only a negligible amount of heat is lost while coming to equilibrium.

Third Law of Thermodynamics.—Equation (13) may be integrated from zero temperature up to any given temperature.

$$S - S_0 = \int_0^T \frac{C_p dT}{T}$$

The third law states that the entropy of pure crystalline substances, at the absolute zero, may be taken to be zero, *i. e.*, $S_0 = 0$. Then

$$S = \int_0^T \frac{C_p dT}{T} \qquad (24)$$

and the absolute value of the entropy may be determined from heat capacity data. Since $\Delta F = \Delta H - T\Delta S$, one may calculate ΔF from heat of reaction and heat capacity data.

SEALED TUBE OXIDATIONS *in* QUALITATIVE ORGANIC CHEMISTRY

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SIDE-CHAIN oxidation is a valuable method for identifying aromatic hydrocarbons. Potassium permanganate, in neutral or alkaline solution, is the oxidizing agent most frequently used. In many cases, however, it is not satisfactory, especially in small scale work. Thus, toluene yields only a very small quantity of impure benzoic acid. The method outlined below is of general application, and is of special value in cases where permanganate oxidations do not work. It consists in the oxidation in sealed tubes by means of dilute HNO_3 (sp. gr. 1.2). This method has been much used on the large scale in preparative work, but seldom in qualitative analysis. In this way 0.5 g. of a compound can be identified. It also has the advantage of introducing students to the technic necessary for working with sealed tubes.

METHOD

All the apparatus required can readily be made in the laboratory. It consists of a furnace, bomb, and iron tube which can be closed at both ends.

Furnace.—A piece of $^1/_8$" asbestos, 18" × 9" is cut as indicated by the heavy lines in Figure 1. Two holes 2 cm. in diameter are cut by means of a cork-borer. It is then soaked in water and folded (dotted lines). The ends are folded and fastened with wire so as to form a box. A lid is made similarly. An iron trough is placed in the middle of the furnace, and a hole is made in the lid for the insertion of a thermometer.

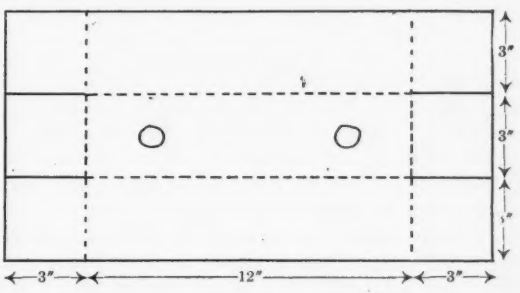

FIGURE 1

The furnace is heated by Bunsen burners placed at the holes. It is advisable to protect the Bunsen flames from draughts.

Bomb.—The bomb is made from thick glass tubing 13 mm. internal diameter, and 20 cm. in length. Hard

glass tubing is generally used, but in many cases ordinary tubing is satisfactory. With the latter, however, the opening of the tube after heating in the furnace is apt to be violent. The tube is sealed at one end, and 0.5 g. of the compound and 5 cc. HNO_3 (d. 1.2) are introduced by means of a filter funnel so that nothing adheres to the walls of the tube. The open end of the tube is heated in the blow-pipe flame, and drawn off into a thick-walled capillary tube about 2 cm. long. The tip of the capillary is then sealed. The glass-blowing required is the same as in the preparation of a Carius tube, and demands a little practice. With the help of an instructor the technic is soon acquired. The tube is placed in an upright position until the capillary is cold.

Iron tube.—Bombs are always heated in iron tubes in case of explosion. The metal case in this case is made from plumbers' iron tubing 9″ long and 1″ external diameter, provided with a screw-thread at each end. The tube is closed, when required, by two couplings, each provided with a block.

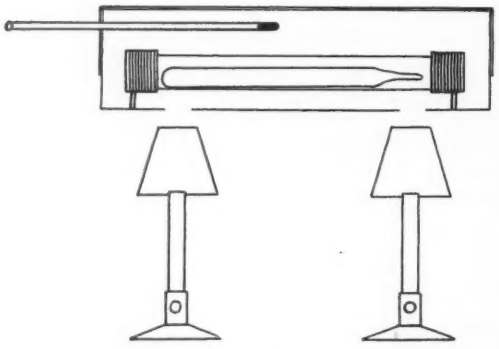

FIGURE 2

Oxidation.—The oxidation is performed as follows. The sealed glass tube after cooling is placed in the iron case which is then closed by means of the couplings. The iron case is placed in the furnace (Figure 2) which is then heated to the requisite temperature for a certain time. When the operation is completed, the Bunsen burners are turned off, and the furnace is allowed to cool. When the tube is quite cold, one of the couplings is unscrewed so that the end of the capillary is just visible. It is heated in a small blow-pipe flame until a small hole is blown in the softened glass. Then, and not until then, is the tube removed from the iron case. *It cannot be too strongly stressed that any sealed tube which has been heated, no matter at how low a temperature, must not be removed from its iron casing as long as it is sealed.* It is also necessary to make certain that all the pressure has been released, as the outlet sometimes is choked with solid which has separated during the oxidation. The end of the glass tube is broken off by scratching it with a glass knife, and touching it with a white-hot glass rod. The contents are filtered, washed with water, and recrystallized to constant melting point from water or aqueous alcohol. If an oil is obtained it is separated, and shaken with warm sodium hydroxide solution. The sodium hydroxide layer is separated, and acidified with concentrated hydrochloric acid. A solid is obtained which is purified as above. The solids obtained are for the most part acids which are identified by their physical constants, such as melting points and neutralization equivalents. In many cases they can be identified by conversion into the methyl esters or amides.

TABLE 1

Compound	*Product*	*Conditions*
Toluene	Benzoic acid, m. p. 121°	150°–1 hr.
Benzyl chloride	Benzoic acid, m. p. 121°	150°–1 hr.
Benzal chloride	Benzoic acid, m. p. 121°	150°–1 hr.
Benzotrichloride	Benzoic acid, m. p. 121°	150°–1 hr.
Mandelic acid	Benzoic acid, m. p. 121°	150°–1 hr.
Acetophenone	Benzoic acid, m. p. 121°	150°–1 hr.
Propiophenone	Benzoic acid, m. p. 121°	150°–1 hr.
Ethylbenzene	Benzoic acid, m. p. 121°	150°–2 hrs.
Propylbenzene	Benzoic acid, m. p. 121°	150°–2 hrs.
Diphenylmethane	Benzophenone, oil	150°–1 hr.
m-Nitrotoluene	*m*-Nitrobenzoic acid, m. p. 142° (*M*)	150°–1 hr.
p-Nitrotoluene	*p*-Nitrobenzoic acid, m. p. 242° (*M*)	150°–1 hr.
m-Nitrobenzyl chloride	*m*-Nitrobenzoic acid, m. p. 142° (*M*)	150°–1 hr.
p-Nitrobenzyl chloride	*p*-Nitrobenzoic acid, m. p. 242° (*M*)	150°–1 hr.
o-Chlorotoluene	*o*-Chlorobenzoic acid, m. p. 142°	200°–3 hrs.
m-Chlorotoluene	*m*-Chlorobenzoic acid, m. p. 158°	200°–3 hrs.
p-Chlorotoluene	*p*-Chlorobenzoic acid, m. p. 243°	200°–3 hrs.
o-Bromotoluene	*o*-Bromobenzoic acid, m. p. 150°	200°–3 hrs.
m-Bromotoluene	*m*-Bromobenzoic acid, m. p. 155°	200°–3 hrs.
p-Bromotoluene	*p*-Bromobenzoic acid, m. p. 253° (*M*)	200°–3 hrs.
**o*-Iodotoluene	*o*-Iodobenzoic acid, m. p. 162°	200°–3 hrs.
m-Iodotoluene	*m*-Iodobenzoic acid, m. p. 189°	200°–3 hrs.
p-Iodotoluene	*p*-Iodobenzoic acid, m. p. 270°	200°–3 hrs.
p-Methylacetophenone	Terephthalic acid (*M*)	150°–1 hr.
Deoxybenzoin	Benzil, m. p. 95°	150°–1 hr.
4-Chloro-*m*-xylene	4-Chloro-3-methylbenzoic acid, m. p. 209°	150°–1 hr.
4-Bromo-*m*-xylene	4-Bromo-3-methylbenzoic acid, m. p. 209°	150°–1 hr.
*4-Iodo-*m*-xylene	4-Iodo-3-methylbenzoic acid, m. p. 218°	150°–1 hr.
Mesitylene	Mixture of acids	150°–2 hrs.
p-Ethyltoluene	Terephthalic acid (*M*)	150°–2 hrs.
p-Cymene	Terephthalic acid (*M*)	150°–2 hrs.
**o*-Xylene	*o*-Toluic acid, m. p. 107°	100°–2 hrs.
m-Xylene	*m*-Toluic acid, m. p. 112°	100°–2 hrs.
p-Xylene	*p*-Toluic acid, m. p. 181°	100°–2 hrs.
o-Nitroethylbenzene	*o*-Nitrobenzoic acid, m. p. 147°	150°–2 hrs.
p-Nitroethylbenzene	*p*-Nitrobenzoic acid, m. p. 242° (*M*)	150°–2 hrs.

* Indicates very small yield.

Acids can be identified by their melting points and by their amides, or, in the case of those acids marked (*M*), by their methyl esters. Ketones are identified by their dinitrophenylhydrazones.

Preparation of Methyl Esters.—Three-tenths of a gram of the acid is dissolved in 4 cc. methyl alcohol containing five or six drops of concentrated sulfuric acid, and the solution is heated on the water-bath under reflux for half an hour. The ester is obtained by cooling the solution, or by the addition of water, and is purified by recrystallization from methyl alcohol.

Preparation of Amides.—Equal quantities of acid and phosphorus pentachloride (excess of the latter must be avoided) are heated above a small flame for a minute and allowed to cool. Concentrated ammonia is then added drop by drop from a pipet. The reaction is violent and should be carried out slowly. When

no further reaction is caused by the addition of the ammonia, water is added, and the precipitate is collected on a Hirsch filter. It is washed with cold water, and recrystallized from boiling water.

The value of the method may be seen from the accompanying table which summarizes the results of experiments carried out in our laboratories.

It is obvious from the table that the method is applicable to a variety of compounds. It is especially useful in cases such as toluene and the iodotoluenes where permanganate oxidations are unsatisfactory.

ACKNOWLEDGMENT

Thanks are expressed to the Carnegie Trust for the award of a Teaching Fellowship to one of us (Neil Campbell).

DISPLAYING CHEMICAL EXHIBITS*

EGBERT K. BACON

Union College, Schenectady, New York

THE display cases for chemical exhibits that are illustrated and described here are in use in the chemical laboratory of Union College. The cases, which were all designed and constructed in the chemical laboratory, afford an effective and inexpensive means of placing on permanent display typical exhibits of materials that are associated with the most important chemical industries.

The educational value of chemical exhibits may be lost easily through improper display. It is frequently customary to place exhibits in large wall cases, which are usually located in a room designated as a chemical museum. Another common plan is not to place exhibits on permanent display, but to store them in boxes or cupboards.

The disadvantage of the first method of handling exhibits is that they may be seen only by a special visit with, perhaps, the dead impressions of museum curios. Furthermore, large masses of material grouped together have a bewildering effect on the observer, with resulting disinterest. Storage of exhibits may keep them clean and intact, but does not permit prolonged display, as their use may be confined to a single hour's exhibit on the lecture table.

One solution to this problem of display is by use of small glassed-in wall cases. These cases have been standardized to overall dimensions of 29″ × 30½″ and about three inches in depth. The sides of the cases are constructed of half-inch cheap lumber, fitted and held together by 2″ × 3¼″ angle irons. The backs are constructed of composition board, and angle irons, fitted at each back corner, give the frame rigidity. The boards of which the sides are constructed are rabbeted both front and rear to admit ordinary standard 28¾″ × 30″ window glass in front and the composition back in the rear. Wooden strips ¾″ × ¼″, which are screwed into the frame, hold the glass in place. As many shelves as may be desired are fitted into the frames and held by nails through the sides. The nail holes are countersunk, filled with putty, and the entire case painted a flat white or cream color to harmonize with the walls on which they are hung. Figure 1 shows three of these cases mounted on the wall of the Chemical Laboratory.

FIGURE 1.—EXHIBIT CASES ON WALLS OF CHEMICAL LABORATORY SHOWING DETAILS OF CONSTRUCTION AND ARRANGEMENT OF EXHIBITS

Each case is devoted to a single exhibit or, at the most, to not more than three exhibits. These need not

* Presented before the Division of Chemical Education at the ninety-third meeting of the A. C. S., Chapel Hill, North Carolina, April 13, 1937.

be related in any way, but are selected to give balance and color to the entire case. For example, the almost too colorful nature of a case devoted entirely to synthetic plastics and the too colorless nature of an exhibit of rubber or neoprene may be off-set by a combination of the two.

We have thought it best to let each exhibit speak for itself, although a neatly lettered sign for each gives the nature of the exhibit and credit to the manufacturer

FIGURE 2.—ILLUMINATED SHOWCASE FOR EXHIBIT OF BULKY MATERIALS

furnishing it. In some instances, where further information seems necessary, small typed cards give the required description.

Where the manufacturer has supplied a mounted display, we have built the case around the display board, following the procedure as described for the standardized wall cases.

Where the bulkiness of the material to be displayed does not permit inclusion in one of these cases, we have placed it in an ordinary showcase equipped with showcase lights. This, however, has the objection, as previously mentioned, of massing together too much unrelated material. Figure 2 shows the effect of the lighted showcase.

For the most part, we have placed the exhibits on the walls flanking the lower corridor of the chemical laboratory through which everyone must pass to gain access to the various offices and laboratories. Here they do the maximum of service. Some cases have also been placed on the other floors of the building where wall space is available and where the exhibit will show off to advantage. Figure 3 shows the general effect obtained as one enters the lower corridor of the Chemical Laboratory.

One objection to the type of wall case described here is that material cannot be easily removed when once arranged. This could be overcome by construction of a hinged glass door that may be locked instead of the glass held in by screws. However, this adds both expense and some extra labor to the construction. On the other hand, this condition may be really an advantage as material cannot be disarranged, broken, or lost in the process of repeated removal.

If there is not enough wall space to display all the exhibit material on hand, there may be a planned rotation or change of cases, or the material in them.

Another use to which these cases may be put is to the display of certain laboratory preparations such as crystals, colloidal systems including sols, liesegang rings and other gel reactions, inorganic and organic preparations, etc.

The advantage of displaying exhibits in the manner described here may be summarized as follows:

First, the displays are all single units or several smaller units, which may be arranged in a colorful and attractive manner. They do create and hold interest.

FIGURE 3.—VIEW OF EXHIBIT CASES AS SEEN FROM ENTRANCE TO CHEMICAL LABORATORY

Second, they are constantly on view to students passing to and from classes. Visitors find them a continual source of interest.

Third, the displays remain intact and free from dust and other contamination.

Fourth, they permit the bare walls of a chemical laboratory to contribute to the cause of visual education.

These displays would not be possible without the generous coöperation of numerous manufacturers of chemicals and chemical products. While the sources and types of material have been far from exhausted, we have at present sixty-eight different displays that have been contributed by sixty-two different manufacturers. Our requests for material have been modest, and rarely have we found a manufacturer unwilling to coöperate. The displays may be classified under the following

groups: Chemicals, organic and inorganic; Cellulose and Cellulose Products; Electrical Supplies; Food Products; Metals and Metal Products; Paints, Pigments, and Varnish; Petroleum Products; Silicates and Glass; Synthetic Plastics and Resins, and Miscellaneous.

A QUALITATIVE TEST FOR TIN IN THE PRESENCE OF ANTIMONY

DONALD BOOK*

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EDITOR'S NOTE.—*Oberlin freshmen are encouraged "to do a little inventing," as Professor Holmes puts it. The accompanying note is published, not only for its intrinsic interest, but as an example of the kind of work an interested and intelligent freshman can do.*

THE usual method of testing for tin, namely, the reduction of $HgCl_2$ to insoluble HgCl by divalent tin ions, is in many cases an unsatisfactory test because the precipitate of HgCl is not always heavy enough to be conclusive. Furthermore, the original solution containing the divalent tin is often somewhat cloudy. The reduction of $Bi(OH)_3$ to free bismuth by a solution of Na_2SnO_2 seems to be a more conclusive test for tin than any other. When NaOH is added to a solution containing both antimonous and stannous ions, the following reactions occur.

$$SbCl_3 + 3NaOH \longrightarrow Sb(OH)_3 + 3NaCl$$
$$SnCl_2 + 2NaOH \longrightarrow Sn(OH)_2 + 2NaCl$$

Excess hydroxide gives

$$Sb(OH)_3 + 3NaOH \longrightarrow Na_3SbO_3 + 3H_2O$$
$$Sn(OH)_2 + 2NaOH \longrightarrow Na_2SnO_2 + 2H_2O$$

Addition of the solution of the antimonite and stannite to $Bi(OH)_3$ should give free bismuth if Na_3SbO_3 does not interfere with the action of the Na_2SnO_2.

$$2Bi(OH)_3 + 3Na_2SnO_2 \longrightarrow 3Na_2SnO_3 + 3H_2O + 2Bi$$

Providing Na_3SbO_3 does not also reduce $Bi(OH)_3$, the appearance of free bismuth when the solution of Na_3SbO_3 and Na_2SnO_2 is added to $Bi(OH)_3$ is a good test for tin. We must also consider whether or not the analytical procedure will admit other ions, especially those of group IIB, to the antimony-tin solution which may interfere with the formation or with the action of Na_2SnO_2.

If, then, three conditions are satisfied, if (1) Na_3SbO_3 does not reduce $Bi(OH)_3$ to free bismuth, if (2) Na_3SbO_3 does not interfere with Na_2SnO_2 in the reduction of $Bi(OH)_3$, if (3) the presence of other group IIB ions does not hinder the formation or the action of Na_2SnO_2, then the reduction of $Bi(OH)_3$ by Na_2SnO_2 is a good test for tin ions.

Experiments to test these conditions, (1) the effect of Na_3SbO_3 upon $Bi(OH)_3$, (2) the effect of a solution of Na_3SbO_3 and Na_2SnO_2 upon $Bi(OH)_3$, and (3) the analysis of two known solutions, the first containing arsenic, mercury, and antimony, and the second containing arsenic, mercury, antimony, and tin show the conditions to be satisfied and therefore that the $Bi(OH)_3$—Na_2SnO_2 reaction is a good test for tin ions. In experiment (1) the Na_3SbO_3 produced no effect upon the $Bi(OH)_3$. The appearance of unmistakable black bismuth in experiment (2) also showed satisfactory results. Experiment (3) indicated particularly what impurities could be expected in the solution of $SbCl_3$ and $SnCl_4$ after Sb_2S_3 and SnS_2 were dissolved in $9N$ HCl. In most cases when HgS is present, the solution of the antimony and tin salts is milky. This turbidity can be reasonably explained by the presence of some HgCl because HgS is partially soluble even in cold $9N$ HCl. Some $HgCl_2$ may also be present, but there is no other impurity of a noticeable amount in the antimony-tin solution. Those named above did not affect the Na_3SbO_3 or the Na_2SnO_2. In this test, as in the more common test for tin, it is necessary to reduce the $SnCl_4$ completely to $SnCl_2$ with nascent H_2; otherwise Na_2SnO_3 will be formed from the $SnCl_4$ and no reduction of $Bi(OH)_3$ can take place.

(1) $2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$
(2) $SnCl_4 + H_2 \longrightarrow SnCl_2 + 2HCl$
(3) $SnCl_4 + 6NaOH \longrightarrow Na_2SnO_3 + 4NaCl + 3H_2O$†

* During 1935–36 Mr. Book was a student in the general chemistry class at Oberlin College. It is significant that a student in his first year of college chemistry could work out the problem of this paper independently. He was not aware of the fact that Vanino and Treubert had developed this test in 1898.

† Although in many reactions there is a marked similarity between the properties of tin and antimony, most probably explained by the positions of the metals next to each other in the periodic table, Na_3SbO_3 does not behave illogically in not reducing $Bi(OH)_3$. The periodic table shows that antimony is slightly less metallic than tin and, therefore, does not oxidize so easily as tin. Consequently, a stronger oxidizing agent than $Bi(OH)_3$ seems necessary to change Na_3SbO_3 to Na_3SbO_4.

The CHEMIST *at* WORK

ROY I. GRADY AND JOHN W. CHITTUM

The College of Wooster, Wooster, Ohio

VI. MEDICAL TECHNOLOGIST

ELEANOR BREITWIESER

The position described by Miss Breitwieser is sometimes referred to as that of laboratory technician. Recently she passed an examination given by the American Society of Clinical Pathologists and she is now a registered Medical Technologist.

Miss Breitwieser was graduated from the College of Wooster in 1933. Immediately after graduation she worked for fifteen months as a student volunteer in the laboratory of the Western Pennsylvania Hospital in Pittsburgh. Her first position was in a private clinical laboratory. She is now employed by the Allegheny County Hospital at Woodville, Pennsylvania.

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Until the twentieth century, the female of the species was about as rare in the field of chemistry as a pair of rubbers at the Presidential Ball. But, fortunately for the already mentioned female, this doesn't hold true today. Chemistry offers numerous opportunities for life work, or even a temporary means of earning a livelihood.

It has always remained a mystery to me how I started my collegiate work as an English major and ended it as a hospital laboratory technician. But here I am. And that's that.

I think perhaps the description of a day in the lab will best express the technician's life and work.

Br-r-r-r-r. There goes the alarm. It's six-thirty. Time to get up. It's cold, too. But time and climate are no respecters of persons. A few more stolen minutes of sleep; then out into the cold room. A bite of breakfast and a dash for the seven-fifteen car. Then arrival at the hospital, and life begins at 8:40.

First we encounter the long line of patients from the dispensary. Their wants are varied. There is stout Mrs. Capella who is diabetic and wants a blood sugar analysis. She has probably broken her diet again and wants to see just how much damage it has done. Behind her is Daniel Boone, a middle-aged colored gentleman who is just recovering from sickle-cell anemia. He is waiting to have his blood count taken. Then there is Jenny O'Hara who is a hyperthyroid. She is waiting for a basal metabolism test to see whether or not she must undergo an operation. Five or six new patients make up the remainder of the little group. They may want anything from a Blood Sugar to a Wasserman Reaction.

We must take care of all these patients, while an interne goes through the hospital itself, taking bloods, throat cultures, blood counts, and so forth. At the same time Jimmy, the messenger boy, hurries to the different pavilions to collect urine specimens, sputums for microscopic examination, and racks of tubes containing specimens for gastric analysis.

This much accomplished, we plan to spend the remainder of the morning actually analyzing the specimens collected. But then one must not make too definite plans in a hospital laboratory, for anything may happen. And we are not disappointed. Just as everything is well under way, word comes through from the Front Office that there is to be a post-mortem examination within an hour. Immediately the pathology department springs into action, and our interne who regularly assists with the lab routine rushes off to the post. Oh, welcome change.

Luckily the remainder of the morning proves uneventful, and the arrival of lunch time finds us ravenously hungry, making our final reports on the morning's work. We take the elevator to the fifth floor where we partake of Wednesday's lunch of vegetable soup, roast beef, and browned potatoes with the inevitable custard for dessert. We are scarcely seated when the dining room phone jingles discordantly in our ears, and Miss Miller has to leave immediately to do a special blood count on a little girl who has just been brought into Emergency. The doctor on her case wants an immediate report, as he suspects appendicitis. Incidentally, it is an ancient and honorable custom for all emergency cases to arrive at the most inopportune moment of the whole day.

After lunch the laboratory staff divides its forces. Some go to pathology to make preparations for the frozen sections which must be made as a result of the morning's post-mortem. Some go to bacteriology to examine smears and cultures. One girl goes to assist Dr. Russel with typing a group of people. They are willing to be donors for the blood transfusion which must soon be given to little Betty Naylor if she is to survive her blood stream infection.

The rest of us go to the third floor to assist Dr. Arthur who is doing some valuable research on the problem of pneumonia. This is the best part of the whole day, for we all like Dr. Arthur. His unassuming

manner and sincere devotion to his life work make him a constant source of inspiration to us all. It is association with people like Dr. Arthur that creates in us the desire for greater knowledge, and urges us to give the best we have to our own immediate tasks. Dr. Arthur has not only inspired us, but has helped us in a material way. It is through his efforts that those who wish to do so may go to the University part time for graduate work. Is it any wonder, then, that we welcome an opportunity to work with him?

Today we are doing a series of skin titrations with the diphtheria toxin. We shall use rabbits, and will infect them with different dilutions of the toxin. We will give the infection intracutaneously, that is, between the layers of the skin. We must exercise the greatest care that the point of the needle does not penetrate below the skin layer. This would entail an acute infection in the rabbit and bring disastrous results.

At four o'clock we reluctantly return to our own laboratory where we take care of the four o'clock collection. This completed, we spend the remainder of the day replenishing reagents from stock solutions and preparing for tomorrow's work. Thank goodness we don't have to wash our own apparatus at this hospital.

Five o'clock and the day is done. Oh no, it isn't. There goes the dinner gong. And tonight we shall hear the Boston Symphony.

I've tried to describe a typical day in my laboratory life. To be sure there are many days in which there is absolutely nothing to relieve the daily routine. On some days there is so little scheduled work that one must find his own amusement by reading in the hospital library, or by planning new enterprises, or, being human, by relaxing over a good cup of tea. Again, there are days on which everything goes wrong, and everybody in the world wants something at once. On these days, schedules are shot to pieces, and methodical souls go mad.

In small laboratories one or two persons can handle all the necessary tests. In larger laboratories the work is divided into departments: biochemistry, which includes blood chemistry, urine analysis, gastric analysis, and basal metabolism work; bacteriology, which includes all smears, cultures, serums, and Wasserman reactions; and pathology, which includes blood counting and examining gross specimens and slides made from frozen sections from diseased organs.

This, in general, is the technician's work, though she may rightly expect to do anything. Sometimes cases of suspected poisoning will require special attention. Occasionally she may find herself doing a milk or water analysis. And at one time, I recall, we even had to analyze a fur neck-piece.

I have never been sorry that I became a laboratory technician. The work is exacting, but not tiring. It is seldom dull. I like the clean, orderly, hospital laboratories that are a distinct contrast to those found in so many industrial plants. Almost every day I have learned something new and interesting. But perhaps the greatest attraction for me in this work is a sense of inward pleasure that comes from the knowledge that someone is going to be better and happier as a result of information obtained through the laboratory.

I shall never forget a young colored boy from St. Barnibas' Home. He was brought to the hospital with a bad heart condition accompanied by extreme hyperthyroidism. By means of a series of basal metabolism tests which we gave to him, the staff physicians were able to tell just when was the best time to operate. The operation was a success. And about four months later I happened to meet this boy on the street. I scarcely recognized him as the same nervous thin youngster who had been a patient in the hospital. I remarked about his changed appearance, and of his own accord he told me that not only was he better physically but he was no longer haunted with the fear of death as he had been when I knew him as a patient. Although we in the laboratory had only a small part in assisting with this change, it has made me feel very happy.

[Miss Breitwieser was asked to indicate the training and requirements desirable in the hospital technician. She responded with the paragraphs following.]

Any self-respecting technician would want at least four years of college training with especial emphasis on organic and food chemistry. She would want at least an introduction to biology with bacteriology whenever it is possible. At present there are either hospitals or universities in nearly all the large cities which offer courses (about one year) in special training. However, those college graduates who lack money for such special training may break into a position by first working as a volunteer in some accredited hospital lab. Here one must put to use his own knowledge, and under his own initiative learn the work through actual experience.

The personal characteristics necessary for success in this field are in general no different from those which bring success in any field. More especially we technicians need absolute honesty in all our work. We must be resourceful. And last but not least, that which is hardest of all for woman, we must learn to accept gracefully the criticism that is bound to fall when we publish the results of one of our pet schemes or even of our life work. But in the life of a chemist this criticism is about as inevitable as his lack of money. Indeed, if any of my coworkers chances to read this article he will probably criticize me for the way in which I've written concerning the laboratory technician.

VII. ACTIVITIES OF THE CHEMIST IN SUGAR INDUSTRIES

WILLIAM D. HORNE

The writer of this seventh article is Dr. William D. Horne, a consultant chemist of Beech Creek, Pennsylvania. He received the Ph.B. degree from the Columbia School of Mines and his Ph.D. in Chemical and Mechanical Engineering from Columbia University.

Dr. Horne has served on the faculties of Columbia University and of Rutgers University. He has also been a member of the editorial staff of Industrial and Engineering Chemistry. *His major activity has been in the field of sugar refining. He has held a number of situations as chief chemist and as consulting chemist for various sugar refining companies. For some seventeen years he was associated with the Cuban American Sugar Company and for another five years was chief chemist of the Hershey Corporation, Cuba.*

Dr. Horne has been a member of the American Chemical Society since 1886 and of the Society of Chemical Industry since 1895. His publications have appeared in the journals of these societies and of two others of which he is a member. During this period he has helped to establish some of the major improvements in refinery practice.

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To those wishing to follow a professional career that will afford a broad field of opportunity in intellectual development as in material success, chemistry will always hold out alluring prospects. One should try to follow some calling for which he feels an enthusiasm so that his work will be a joy and not a burden to him. It is here that chemistry makes strong appeal, for its range is wide; and its revelations of nature's workings, its methods of attacking these problems, its promises in solving them, and its power in turning them to intellectual and practical use are captivating alike to persons of all sorts of temperaments.

Whether one specializes in highly theoretical research, gives himself to teaching or goes in for industrial work, there is so much overlapping of theory and reality in all, that the same interests pervade all fields of work, though in differing degrees. In the industrial field one has probably the most general mingling of theory and practice exemplified, for modern industry moves on with stupendous force, necessitating the greatest precision of operation, the nicest knowledge of materials employed, and the most exact maintenance of standards in all that is produced. And accompanying these exacting details of production are the continual studies of world conditions of supply and demand, the changing tastes of the public, the international relations of tariffs and markets with their influences on the characters of raw materials and finished products. All these forces influence the methods of industrial work, demanding study, experiment, and research of the highest type and call for vast expenditures of effort and money that only the powerful can bear.

Chemistry in industry associates closely with engineering and with electricity and continually coöperates with physics, of which, indeed, chemistry may be considered a special phase. To be proficient in any of these branches one must have a fair familiarity with the others. This broad acquaintance with the fundamental branches of knowledge gives one a wonderful satisfaction in feeling at home in the universe of which he is a part. Thus all serious work in any of these branches is ennobled, and rightly brings reward to those who toil along.

Among the long list of industrial enterprises of our country and its immediate connections where chemistry plays an important rôle is the sugar industry, supplying one quarter of our food energy and rightly looked upon as providing one of our indispensable commodities as well as almost the cheapest of foodstuffs.

Nearly a quarter of our six million tons of sugar consumed annually is produced on our continent in the form of beet sugar, while the balance is cane sugar, coming as raw sugar, principally from Cuba and our island possessions as well as, in small part, from Louisiana and Florida. This raw sugar passes through our continental refineries, of which there is less than a score in operation. Another division in the sugar field is the corn sugar industry, a true child of chemical invention and research, whose strength today is the immediate result of unremitting and tireless effort through a century and a quarter. Then there are branches of the industry devoted to the production of many millions of gallons, annually, of cane syrup, corn syrup, sorghum syrup, and maple syrup, together with moderate amounts of maple sugar and milk sugar. One looks forward, also, to the probable rapid approach of the time when the world will be enriched by the commercial arrival of levulose, sweetest as well as most soluble of all the sugars—and the most digestible—as the result of brilliant and aggressive chemical research by American chemists.

Modern industrial sugar establishments are usually huge affairs, magnificently equipped with every facility for economical mass production and skilfully, scientifically operated so as to crowd the last pound possible through their intricate maze of machinery and operations. All this calls for the most thoroughly organized and conducted chemical control, wherein multitudinous results must be obtained with dispatch and precision as well as at the minimum expense. Raw materials and finished products are analyzed and tested and in-

termediate products are tested to determine the exact placement and treatment of them as well as the thoroughness of the operations of manufacture.

The chief chemist in the laboratory supervises the work of the routine operators, the standardizing of apparatus and reagents, the compilation of results obtained, the writing of reports; and takes the lead in all investigations and experiments. As parts of the laboratory work are continuous there are usually two or three shifts of work in the twenty-four hours. The most common test in raw sugar house and refinery laboratories is that for the so-called quotient of purity of the various solution, whether it be juice from the mills, diffusion batteries or defecators, thick juice from the evaporators, massecuite from vacuum pans, syrups from the centrifugal machines, or final molasses from the spinning of the lowest massecuites. These tests are made by taking the density of the solution with a Brix hydrometer or by a refractometer and polarizing the solution clarified by means of subacetate of lead. The complete test can be made in three minutes. All sugars produced are polarized to determine their percentage of sugar. The ash, invert sugar, and moisture are also determined in these and other materials at frequent intervals.

The laboratory further makes analyses of soils, fertilizers, oils, water, sugar cane and beets, fuel, limestone and burnt lime, and many other things. In refineries the list is much the same as in raw sugar factories, adding bone black to the list of raw materials and checking on each stage of its handling in filtering the sugar solutions. Color and pH are also of great importance and are checked at every step in manufacture and refining. Fermentation is a matter to be guarded against and sometimes calls for bacteriological investigation.

In the sugar industry most of the major processes of chemical engineering are involved, such as crushing, shredding, and disintegrating, in the case of sugar cane, washing and slicing, as in the case of beets, heating, cooling and evaporating, defecating and carbonating, sedimenting, decanting, and filtering in many ways, destructively distilling in bone-black retorts and fractionally oxidizing in decarbonizers, crystallizing in vacuum pans and crystallizers, separating crystals from mother liquor in centrifugal machines, washing crystals with syrups and with water, drying in granulators, pulverizing in various types of mills, packing different products in their individual types of containers, and many other operations common to all power plants and industrial establishments.

The field for study and research is endless, made the more attractive by a literature so rich as to have few rivals in the technical world. New situations constantly arise, calling for special treatment, new products have to be developed to supply novel demands in trade. For instance—the boilers are priming badly and the plant has been held back for a day. Hurried examination fails to find the cause. The next best thing is to find a cure. A bucketful of subacetate of lead solution in the boilers stops the priming and the plant steams up, full speed ahead. Or again, the char-filtered liquor comes off the char pinkish instead of colorless. The color is baffling, but intense experimenting shows it to be due to iron combined with some tannin-like material. A slightly heavier defecation of the raw sugar solution with phosphoric acid and lime enables the flocculent precipitate formed to gather up the troublesome colloidal coloring matter, and the difficulty is gone. Again, some grayish granulated sugar was traced to cloudy char filtrates from the Vallez filters, using paper pulp. This same filtrate looked clear until examined by a Tyndall beam of light, which revealed the cloud. A little longer running of the Vallez filtrate to the cloudy-liquor tank before turning it to the clear-liquor tank stopped the trouble. In another instance, dilution of sugar solutions, during testing, with subacetate of lead solution introduced errors, at times, in certain calculations. Dry subacetate of lead was prepared and used, eliminating the errors. Then it was found to eliminate, also, the error due to the volume of the precipitate in testing raw sugars, and now it is used as standard the world over. Once more—it became evident there was considerable duplication of effort between raw sugar making and refining. Several years' energetic work on the matter in the tropics solved the problem, so that now fully refined sugar is produced on the tropical estate at a considerable saving as compared with the usual practice.

Such are a few examples of the diversified nature of the sugar chemist's work. The laboratory is the conning tower of the establishment. Through its direction the chemist is in a position to learn the uttermost details of the processes of the plant, and by supplementing this with proper engineering knowledge he can master the entire technic. He should learn all he can of the business as a whole in both its local and world relations. He should strive persistently and sincerely to make himself as useful as possible and should consider his knowledge of chemistry and other things merely as tools to enable his abilities to find their highest degree of expression. There is then no limit to the advancement he can make.

[A man who has acquired considerable prominence in a given profession during a period of fifty years is qualified to give advice to others. For this reason we are including the entire outline of Desirable Training and Personal Characteristics of an Industrial Chemist, which was prepared by Dr. Horne.]

I. Professional career.
   A. Establish position.
      1. Scientifically.
         (*a*) Join leading scientific societies and associations.
         (*b*) Write professional papers for publication. Give lectures.
      2. Industrially.
         (*a*) As a useful cog in an important enterprise.

(*b*) As a leader or owner.
3. Financially.
(*a*) Save when possible.
(*b*) Invest in sound enterprises, avoid great risks, keep solvent.
(*c*) Act promptly on decisions.
B. Personal affairs.
1. Travel. Visit foreign countries, expositions, universities, museums, industrial plants.
2. Coöperation.
(*a*) Follow plans of superiors ardently.
(*b*) Train assistants carefully.
(*c*) Encourage all optimistically.
II. Training.
A. General.
1. Language.
(*a*) Knowledge of Latin, French, German, some Greek. Clear, logical style in speaking and writing.
(*b*) Public speaking.
1. Stand up, speak up, avoid mannerisms.
2. Speak without hurry or hesitation.
3. Keep headlines in mind, avoid tangents.
2. Cultural courses: history, philosophy, logic, art.
B. Special.
1. Mathematics, physics, geology, mineralogy, crystallography, botany, zoölogy.
2. Chemistry—general, analytical, industrial, physical, electrical, physiological.
3. Law—contracts, patent law, relations to employer.
4. Finance—political economy, banking, investments.
III. Personal Characteristics.
A. Health—maintain it scrupulously.
B. Deportment—be a gentleman in thought, word, and act. Dress neatly.
C. Personal relations—be attentive, sincere, dependable. Acquire wide acquaintance with worth-while people.
D. Study—books and journals, scientific and trade. Follow trend of affairs political, social, economic.
E. Amusements—in moderation.

VIII. RESEARCH WORK IN A GOVERNMENT LABORATORY

E. O. WHITTIER

Mr. Earle O. Whittier is senior research chemist in the Bureau of Dairy Industry of the U. S. Department of Agriculture. His academic training was taken at the University of Maine where he received the B.S., M.S., and Chemical Engineering degrees. He spent six years in teaching at the University of Maine and at Simmons College. Mr. Whittier was research chemist with E. I. du Pont de Nemours and Company for three years before going to his present position in 1921.

Mr. Whittier is the author of a number of papers dealing with the work of his department. These have appeared principally in the Journal of Dairy Science, Journal of the American Chemical Society, *and* Industrial and Engineering Chemistry.

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This is intended to be a picture of typical activities of a research chemist in a laboratory organized for work on utilization of dairy by-products. Methods of work in food research laboratories in general do not vary a great deal, but the tools of research and the details of technic may vary considerably.

Research problems, even those arising from a single industry, are not monotonously similar. The determination of fundamental physical constants of substances and the pioneer development of a chemical reaction into an industrial process are widely different in detail, yet these and intermediate problems are all found among the projects of an organization under such an apparently very limited title as a dairy research laboratory. Furthermore, many research problems require the services of persons trained in several branches of science. Consequently, a food chemist may find himself coöperating with manufacturing experts, bacteriologists, physiologists, and those trained in branches of chemistry other than his own.

The chief of this laboratory believes that, if he selects a man with adequate training and experience and with a personality harmonious with research, assigns him a problem, furnishes him with adequate assistants and apparatus, provides him with access to the essential literature and with the opportunity to discuss his problem with associates working on similar problems, in a reasonable time results of interest to science and of value to industry will appear. This has proved to be a justified belief, and such an environment is probably to be found in most successful research laboratories.

The work of a project leader is largely planning what is to be done and how it is to be done, making sure that the facts already known are at hand, evaluating the

results obtained, and preparing reports and accounts of the work for publication.

A man in charge of a research problem usually has assistants—persons adequately trained, but lacking experience sufficient for them to be permitted to carry out research by themselves. They gradually advance to a more independent status. Their work is mostly in the laboratory, weighing, precipitating, filtering, distilling, dissolving, making readings with instruments, calculating and recording data—monotonous sometimes, but always with the possibility of an exciting result just ahead, with the assurance of a problem of a different sort soon, and with more responsibility not far away.

In any chemical research laboratory will be found the balances, burets, beakers, flasks, condensers, and burners familiar to one who has had a laboratory course in chemistry. In this milk research laboratory will be found, also, such items as potentiometer assemblies for measuring hydrogen-ion concentration, small centrifuges and filter presses, sterilizers, small vats of wood or metal, a miniature milk evaporator, colorimeters, dough mixers, a baker's oven, and a miniature paper-coating machine.

Current scientific journals are circulated among the desks of the research men and books and bound volumes of periodicals are delivered on special request. Accounts of projects in progress or completed are given at frequent laboratory staff luncheons. Papers on completed researches are prepared, read at meetings of scientific societies, and later are published in the scientific or technical journals.

An outline of the work done on a research project recently completed will give a picture of typical activities in these laboratories. This work was in progress for nearly three years. The problem was, first, to determine what tests, of those that may be applied to commercial casein, give definite information as to the properties desirable for its use in the coating of paper, and, second, to determine what are the essential features of a manufacturing procedure that will consistently produce casein having these properties.

The problem was first planned in a general way. About fifty samples of commercial casein were to be obtained and submitted to several of the most favored commercial tests and analyses. Then, about twenty samples were to be selected, representing the principal differences in composition and physical properties. These were to be analyzed for all the significant constituents and tested by all the tests known to be used industrially. Each of the twenty samples was to be used in coating paper, the same method of preparing and applying the coating to be used in each case. The coated papers were to be tested, judged, and compared with one another and the coating results correlated with the analyses and tests. After this, casein would be made with all reasonable variations in method and the resulting products rated by these significant tests. Coatings would be made with the samples that showed conspicuous differences by the laboratory tests. From these experiments, a recommended procedure for manufacture of casein for paper-coating would be formulated.

After the plan had been mapped by the project leader, with suggestions from his assistants, the samples were obtained and the long task of making the analyses and tests was undertaken by the assistants. In the meantime, the project leader was searching the literature and corresponding with the manufacturers and users of casein in order to find out as much as possible of what was known, believed, thought, or assumed regarding relationships between tests and coating quality. New methods of testing were tried, and, unless showing no differences among the samples, were added to the list. Arrangements were made with a paper laboratory in another government department to prepare, test, and apply the coatings, and with the Government Printing Office to make test printings of the coated papers.

When this work was completed and the results were compared it was found that only a very few tests showed correlation with coating quality. Our results were given in a paper before a technical association of paper manufacturers and published in a technical journal. Several brief problems of relationships among tests had appeared and these were worked out independently by the assistants by means of more analyses, strength tests, and polariscope determinations, and were published by them.

From this research an accurate idea had been obtained of the basis of the chief complaint of the casein users and of how to test the casein for its liability to cause the defect involved. Some caseins had the property of causing the coatings to hold foam, which resulted in uncoated spots on the paper. This tendency could be evaluated by measuring the air incorporated into a casein solution under standardized conditions. On this basis a corollary problem was undertaken. Caseins were made in a small vat with all the reasonable variations that could be devised. Acid was added to the skim milk slowly; it was added rapidly; the milk was stirred rapidly during addition of acid; it was stirred slowly during addition of acid; the acid was added without previous dilution; the acid was added at different degrees of dilution; the milk was kept at a high temperature during the precipitation with acid; it was kept at medium and at low temperatures. These trials, and many others, yielded a long series of samples which were tested for tendency to cause foam. When this was finished, it was possible to advise the manufacturer how to avoid the foaming defect in his casein, and, as an unexpected by-product, it was possible to advise the user how to minimize the foaming of a casein solution.

[Mr. Whittier describes the personal characteristics and technical training of research workers in dairy chemistry as follows.]

The personal characteristics desirable in research such as that described in the accompanying article are those which seem, to me at least, desirable for any research man. He must, first of all, be wholly honest and free from prejudice in relation to others and to himself:

that is, for example, he should never allow a preconceived notion as to the results of an experiment (frequently highly desirable in the early stages of a research problem) to influence his interpretation of data obtained. He should try to be the first to uncover his own mistakes and, under all circumstances, prompt to acknowledge them. He should be a natural and persistent questioner as to the causes and implications of things and events, and unwilling to accept conclusions of others without logical and sufficient proof. A small measure of stubbornness, a fair measure of humor, and large measures of patience and coöperativeness complete the list of the essentials.

The technical training desirable for research workers in chemistry of milk and its products consists of courses to give ability to read scientific French and German, practice in written expression, mathematics through calculus, college physics, history of science, at least from one to one and one-half years of organic chemistry as a minimum, one year of physical chemistry, inorganic and organic analytical methods, biochemistry, theory and practice of chemical engineering equipment. Qualitative analysis and courses ordinarily given in dairy departments are purposely omitted. Cultural subjects are highly desirable. Some industrial experience is helpful and experience in teaching is invaluable.

IX. THE CHEMIST IN THE WATER RESOURCES LABORATORY

MARGARET D. FOSTER

Margaret D. Foster received the degree of A.B. in 1918 from Illinois College, Jacksonville, Illinois. In June of 1918 she began work in the Water Resources Laboratory of the Geological Survey of the United States Department of the Interior, Washington, D. C., and has been there ever since. She received the degree of M.S. in 1923 from George Washington University and the degree of Ph.D. in 1936 from American University. Miss Foster has published articles on methods for the determination of borate, calcium, fluoride, manganese, and sulfate, on the composition of surface waters, and spring waters, and has contributed analyses and discussion of chemical quality to Geological Survey and State reports on ground water conditions in many parts of the United States.

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The writer's work in the Water Resources Laboratory of the United States Geological Survey may be divided into three phases—water analysis, geochemical interpretation of water analyses, and the modification of old or development of new methods of analysis.

The analytical work, which is the fundamental purpose of the laboratory, includes the routine precipitation, filtration, evaporation, weighing, and titration involved in the determination of the mineral matter dissolved in natural waters—total solids, silica, iron, calcium, magnesium, sodium, and potassium, carbonate, bicarbonate, sulfate, chloride, and nitrate, and occasionally other constituents—fluoride, aluminum, zinc, borate, hydrogen sulfide, and so forth. This work is not, however, as routine and monotonous as it may appear to be on the surface, because of the great variety of water types, and because the work is done by projects, and each chemist usually does all the work on a given project. There may be ten analyses made for a project or perhaps several hundred. In this way the chemist becomes familiar with the types of water in the area and the relationships that may exist between them. For example, for several years the writer made all the analyses of the ground water work done in Texas by the Geological Survey. The geologists doing the field work made simple field tests—such as chloride, sulfate, and hardness—on samples from most of the wells in an area, or they sent the samples to Washington and the tests were made in the laboratory. When all these tests for the area under study had been made, one of the geologists on the Texas project who was in the office collaborated in study of the results of the tests in relation to the depth and location of the wells, the water-bearing formation, and so forth. Representative wells were then selected to be sampled for more complete analysis. These analyses, with the field tests, give a fairly complete picture of the ground waters of the area. From these data the geochemical relations between the water and the geology of the area are studied—that is, a geochemical interpretation of the water is attempted.

As an example, the Houston-Galveston study may be cited. Several years ago the field geologist made several hundred field determinations of chloride, sulfate, and hardness in waters of the Houston-Galveston area and over a hundred analyses were made in the laboratory in Washington. These analyses and field tests furnished the basis for a study of the relationship between the ground waters and the age and degree of weathering of the formations, the extent of salt water encroachment from the gulf, contamination by salt

water associated with salt domes and other structures in which oil and gas deposits occur, and the movement of the water in the formations. This involves not only critical examination and comparison of the analyses but also considerable study of geologic conditions, processes of weathering, hydrologic principles, and other factors that have a bearing on the subject.

The third phase of the work involves the modification of old methods of analysis or the development of new methods. For example, when the importance of fluoride in drinking water became apparent several years ago the method used for the determination of fluoride by several investigators was the same as that used for its determination in phosphate rock. It was necessary to determine whether any of the constituents usually found in water affected the results. It was found that the method was not adapted to the determination of the small quantities of fluoride found in water and that the sulfate in water affected the accuracy of the results. Several other methods were then studied. During the course of this work it appeared that the effect of very small amounts of fluoride on the color of ferric thiocyanate could be measured quantitatively and this means of determining fluoride in water was developed.

The amount of time devoted to any one phase of the work varies greatly from time to time. Days, weeks, even months may be spent studying a method—running through the procedure on known samples, devising modifications, testing the results obtained by these modifications, until a satisfactory procedure is evolved or the method is discarded as hopeless; for several months the whole time may be spent making analyses or studying the results of analyses and writing; or again, several projects may be carried along almost simultaneously as the circumstances require.

[In describing the training and personal characteristics required in such work as she has described, Miss Foster has included some important points not hitherto mentioned in this series of articles.]

Training.—It is essential that the prospective chemist be well grounded in inorganic, quantitative, and physical chemistry; it is not so essential, in the work in this laboratory, that he know so much organic chemistry. With this basic training he can easily be trained in the special methods in use here. Most of the chemists who are in the laboratory now came with only a bachelor's degree. Some have since taken additional work at the various universities in the city at night, earning their master's and doctor's degrees in this way. Those who come in with this higher training must undergo the same specialized training in the methods we use as those who have not had as extensive training.

As for personal characteristics, we like people in the laboratory who have a sense of fairness and coöperation, who are good-natured and even-tempered, neat, quick, and efficient and who are interested in their work and not in the pay, in other words—with a scientific viewpoint and not a laborer's viewpoint. We do not want people who think themselves and what they are doing should take precedence over everyone and everything else, who demand an unfair amount of service from the helpers, who do not do their share of the general work—as the making of new solutions—and who talk too much and disturb others.

X. THE DUTIES OF A CERAMIST IN RESEARCH AND PLANT CONTROL

H. FRAHME

Mr. Frahme is a ceramic engineer with the General Ceramics Company. He was graduated from Rutgers University in 1934 with a degree of B.Sc. in ceramics. He is a member of Phi Lambda Upsilon (honorary chemical fraternity), and is an associate member of the American Ceramic Society and a member of New Jersey Ceramic Association.

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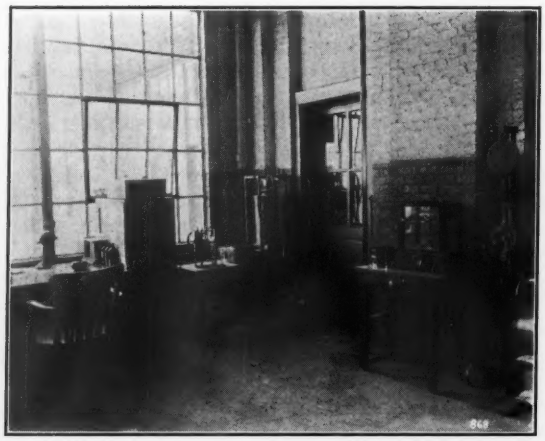
The General Ceramics Company is divided into three large plants grouped within a radius of four miles. One plant is devoted to the manufacture of vitreous china sanitary ware, porcelain sanitary ware, and thermal shock-resisting refractories. Another plant is a specialty shop which manufactures various types of small parts, such as stove units; radio parts including coil forms; tube sockets and suspension bars; pipe liners; chemical filters; electrical porcelain and so forth. In the third plant chemical stoneware is made into innumerable shapes and in weights varying from less than one pound to several thousand pounds.

As can be easily understood from the above list of varied lines of manufactured products, there is a vast fund of technical information to be derived from the inter-relationship of the several plants. In order to use this information to the best advantage and thereby put out a superior product, there is close coöperation among the technical staffs of the various plants. Data on all new developments in research and production in each of the plants are filed and made available to the ceramists in all departments. The maximum benefit is thereby derived from research and development work

done in any one plant. For example, a sanitary ware body may be adapted for use in chemical stoneware if a white product is necessary, or information regarding the casting of stoneware may be of value in the manufacture of heat-shock-resisting refractories. Hundreds of other examples might be cited. In each plant the processes are basically the same. The ware is (1) formed by either dry pressing, wet pressing, jiggering,



A LABORATORY OF THE GENERAL CERAMICS CO., PLANT NO. 1 AT KEASBEY, NEW JERSEY

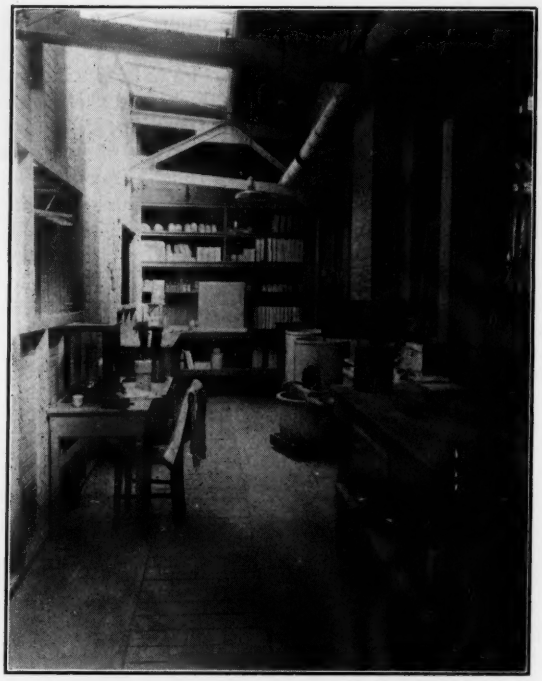
extruding, or casting; (2) dried; (3) glazed by dipping, spraying or painting; and (4) fired. Also, in all cases, with few exceptions, ceramic materials have the same general formula signified by the symbols RO.

In order to simplify this report and at the same time make it more clear, the duties of the ceramist in the chemical stoneware plant will be described. Because of the many methods of manufacturing this ware and the varied conditions it must withstand in service, this job requires the broadest working knowledge.

One of two methods is ordinarily employed in preparing the raw bodies for forming. In the method of preparation used for casting, the clays and other raw materials are thoroughly blunged with water for eight hours. The slip, as the liquid suspension of raw materials is called, is then thoroughly screened and adjusted for casting by getting the proper specific gravity and viscosity. In the other method of preparation used for jiggering, hand pressing, extruding, and molding, the raw materials are blunged with water until all raw materials are thoroughly mixed. The slip is filter pressed into cakes about thirty inches in diameter. These plastic filter cakes are tempered with the proper amount of water and non-plastics, fed into a pug mill, and extruded into chunks weighing about forty pounds. The amount of tempering water added to the filter cakes in the pug mill varies according to the method of forming.

The ceramist in the stoneware plant is responsible for the testing and control of green and fired raw materials, green and fired bodies and glazes, general control of forming, drying and firing, studying the conditions under which the material is used, and, finally, and most important, the development of materials capable of withstanding the various conditions that stoneware must undergo in actual service.

The raw materials used in making stoneware comprise fluxes, clays, and refractories. The fluxes, which are chemically analyzed before shipment, arrive at the plant in quite uniform condition, and, therefore, the only other testing required is that for fusibility, color, and particle size. Refractories are tested for particle size as well as refractoriness and purity. The testing of clays is decidedly more intensive than either of the above due to their very complex nature. Even though the clay used is the most uniform obtainable it is probably the most variable raw material used in ceramics,



A LABORATORY OF THE GENERAL CERAMICS CO., PLANT NO. 2 AT METUCHEN, NEW JERSEY

and, accordingly, one must be doubly sure of its properties before using it. Therefore, the clay is tested both before and after firing.

Unfired or green clay is tested for plasticity, and the amount of water necessary to make the clay plastic is determined. Casting behavior is tested by observing the amount of water necessary to maintain a certain viscosity liquid when a standard deflocculating agent is used. Further tests are run on particle size by screen analyses and slacking time, on dry strength which is so important when handling the material in the unfired

state, and finally on drying shrinkage, which has further short tolerances, due to the fact that it is necessary for a clay while drying, to shrink enough to properly loosen from the mold and yet not so much as to cause excessive cracking and warping.

For proper control of fired properties of clays, the following tests are made after firing in the regular kiln: absorption, linear shrinkage, strength, warpage, and finally the general observance of the fired clay. For example, in examining a fired sample, impurities such as iron or copper are easily detected by black or green spots in the clay.

A LABORATORY IN PLANT NO. 3 OF THE GENERAL CERAMICS CO., KEASBEY, N. J.

Just as it is necessary to test the raw material both before and after firing, so also it is necessary to make a series of tests on every batch of body for manufacture, both in the unfired and fired conditions. Tests on the unfired body include those for dry strength, plasticity, moisture content, dry shrinkage, and speed of drying. Tests on the fired body include vitrification, warpage, ability to take a salt glaze, and, in the event that a loam or bristol glaze is used, to see that both body and glaze have the same thermal expansion so that neither peeling nor crazing will occur.

The most important test for any finished material is the ability to properly withstand service conditions. Certain properties of stoneware are necessary for different conditions. Often a material which will strengthen one property may weaken another. And so it is necessary to have many bodies to fit the many requirements of different divisions of the chemical industry. For example, among the various properties demanded of stoneware are high mechanical strength including modulus of rupture, impact resistance, and crushing strength; resistance to acids, alkalies, and thermal shock; imperviousness to penetrating solutions; ability to be easily cleaned; and innumerable other special requirements.

The ceramist is also accountable for general control of methods of forming which vary with the size and shape of the ware manufactured, and with the type of body used. In connection with this, speed of drying is very important, and the technical man is held accountable for proper drying control. The time for drying varies from three to eighteen days, depending upon the above factors, especially in larger pieces where their bulk does not permit their removal to a humidity-controlled dryer.

The firing rate of ceramic ware must be carefully controlled. If a piece of ware is fired too fast there will be excessive cracking and bloating. On the other hand, too slow firing is very inefficient as only about fifteen per cent. of the fuel used in firing a stoneware kiln heats the ware while the remaining eighty-five per cent. is lost through radiation and flue gases. Firing of most stoneware is carried to a temperature of 2300°F. and the temperature must be controlled to within 15° or else difficulties will be encountered.

Another important duty of the ceramist is trouble shooting. Every manufacturing organization, whether large or small, occasionally runs into manufacturing difficulties that increase loss. A few of the difficulties encountered in ceramics include cracking, warpage, overfiring or underfiring, poor glaze, and discolorations by blemishes generally caused by iron or copper. In locating causes of trouble, experience and logical thought and the proper technical background are very important.

The ceramist is continually confronted with the problem of developing material that will withstand special conditions. Approximately fifty per cent. of all chemical stoneware is made according to drawings sent by the customer. This means that it is necessary for the technical staff to know how material will behave when made up into special shapes.

A short time ago the staff was confronted with the task of decidedly improving the resistance of a product to thermal shock. Before beginning the work, it was necessary to know what were the primary reasons for one body having good thermal shock resistance, while another did not. Subsequently, after experiment and research, it was found that the three primary requisites of a good thermal shock resisting body were low thermal expansion, high thermal conductivity, and high elasticity. Since the elasticity of a ceramic material can only be appreciably changed by making the material porous, that procedure was eliminated. The thermal expansion of the material was then lowered, but since the pieces were quite large it was found that this did not overcome the cracking of the ware. The staff then began stressing thermal conductivity and eventually developed a body with a thermal conductivity at low temperatures of four times that of an average vitreous chemical stoneware material. After running exhaustive tests on the material, it was shown to be satisfactory for the particular requirement.

XI. THE RESEARCH CHEMIST IN THE MANUFACTURE OF ELECTRICAL APPLIANCES

OLIVER G. VOGEL

The physical chemist has an important part in the manufacture of such electrical appliances as ranges, water heaters, and so forth. The author of this article is Research Chemist with the Edison General Electric Appliance Company.

Mr. Vogel received his bachelor's and doctor's degrees from the University of Chicago (1927, 1930). He is a member of the American Chemical Society, the American Physical Society, and of Sigma Xi. His publications have been in the field of physical chemistry.

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My work is concerned particularly with the study and further development of an electrical heating element. The influence of chemistry and the related subjects, physics, and mathematics, on the problem has been very pronounced.

The heating element utilizes a refractory oxide which operates in conjunction with metallic parts at a high temperature (1600–1650°F.). It is necessary that it have stability over long periods of time. This immediately suggests, as will be further pointed out, the need for research on the chemical and physical properties of the refractory, on the heat resistant alloys adaptable to the service, the influence of the latter on the refractory behavior, the development of tests to evaluate the changes introduced and other problems attending the applications of materials to specific requirements of a rather extreme nature.

A critical production difficulty had emphasized the need for study of the factors affecting the electrical resistivity of the refractory in the temperature range of 1000–1900°F. Accordingly, a research program was undertaken to determine and evaluate the variables involved and permit, in so far as possible, the control of the properties desired. Electrical measurements, petrographic study, chemical analyses, and considerations of high temperature interaction between refractory oxides followed. An extensive study of the physical and chemical factors was thus carried on and information of theoretical, as well as practical, importance has steadily been gained. The work has progressed for seven years and remains in a very active state. There have been regular improvements in the quality of the commercial refractory, with the resultant raising of the standards on the heating element. The understanding of the fundamental aspects of the problem has been greatly enlarged. The applications of chemistry and physics have been numerous.

Throughout this work, there persisted the fact that the refractory was only one of the major parts of the element—that it was being used as an electrical insulator between metals operating at 1600°F. or higher. To study the element as a whole, an accelerated life test was developed (as illustrated in the figure). This had to be correlated with tests under conditions more typical of field operations, and the building up of data over a period of many months was necessary. With the adoption of long time tests the refractory problems naturally broadened. In addition, an extensive study of heat resistant alloys was undertaken in conjunction with the metallurgical department.

The life test, which was being used to predict that which one should expect from the long time application of the element in the field, showed that the alloy was not standing up well enough. Thirty or forty different alloys were procured and studied. This resulted in the selection and early change to an alloy which lasted several times as long. Here again, compositional differences and physical properties were emphasized and a knowledge of chemistry and physics lent itself to development of the work. Such subjects as oxidation, intergranular attack, effect of minor constituents and contaminations are among the many which have made the work most interesting and significant to practical application.

IN THIS ROOM HEATING ELEMENTS ARE TESTED OVER A PERIOD OF MANY MONTHS UNDER CONDITIONS TYPICAL OF FIELD OPERATIONS

Although it was learned that one of the best alloys available had been selected, subsequent work has been directed toward obtaining an alloy which will combine the very desirable combination of lower cost with even better properties.

[Dr. Vogel commented upon the qualifications of the research worker as follows.]

The successful carrying out of such a problem makes it necessary for the research worker to become familiar

with the engineering and production phases of the business. It is necessary to take advantage of the design possibilities and to adapt the results to production requirements. The writer was given opportunity for developing experience in these matters. A well-rounded knowledge of the heating element, with its manifold applications and possibilities, was furthered. This has led to activities of a more administrative nature, and this particular department has become responsible not only for the further development and improved quality of the unit—which is primarily a research problem—but also, for the maintenance of standards and the specifications of tests which will assure the quality of the manufactured product.

XII. INVENTION

A. B. MILLER

This contribution by Mr. Miller was written while he was connected with the Paraffine Companies, Inc., of San Francisco. Prior to that connection he held several other positions including one of seven years' duration with the Armstrong Cork Company. Mr. Miller is now a member of the Development Department of the Hercules Experimental Station at Wilmington, Delaware. To this latter concern we are indebted for the photographs illustrating this article.

Mr. Miller was graduated from Franklin and Marshall College with a B.S. in Chemistry. He has published several articles in Industrial and Engineering Chemistry *and is the recipient of several patents with others pending. He is a member of the American Chemical Society.*

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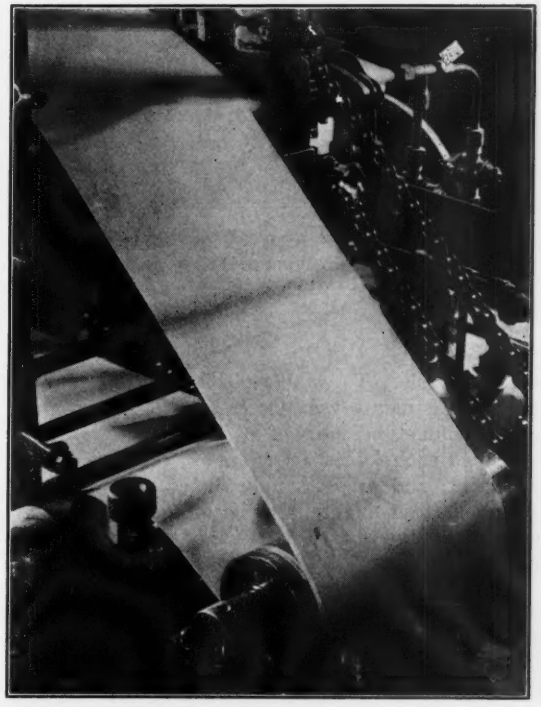
Industry has been dependent in the past largely on the free-lance inventor with his basement workshop as the source of new ideas to be whipped into shape as commercial products. Modern practice has found it more satisfactory to depend for inventions on the men in the organization. They are conversant with the company's current facilities and needs as to processes, products, sales outlets, and expansion trends. In addition, when the invention occurs in the plant its development can frequently be guided to especial advantage by combining the invention and development activity in one group.

In a building products company with the usual control and research groups we have a small flexible group comprising the development department. This consists of my superior and me, chemically trained men, and two non-technical assistants. Without routine and with the facilities of the regular technical departments available, this department can "travel light." Only major problems, especially those on which the time limit is impossibly short, are assigned to it.

A job comes in; we must produce a coated fabric to meet new trade demand. We must catch the fall market. My superior and I go over our available formulas and make what appear to be reasonable changes. Then in rapid succession we run through a series of laboratory samples. In this case one of our first trials rushed through the coating rolls late one afternoon gave promising results. The general program was stopped at this point and attention focused on this run. Two of us worked four days for a duplication of what appeared to be merely a freak effect. Finally temperature and roll-speed conditions were attained which enabled us to reproduce this coating at will.

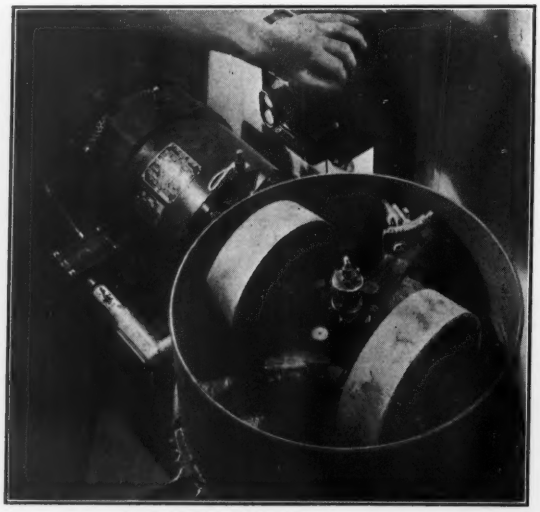


Courtesy of The Hercules Powder Co.
MACHINE FOR EXPERIMENTAL PAPER COATING

Then we were ready for large-scale tests. Since no machine designed for the job was available in the plant, it was necessary to work with the dry end of a paper

machine. The first run judged by the standard of the laboratory sample was unsatisfactory, since insufficient heat could be applied to the finishing rolls to approach the conditions of the laboratory test.

Mechanical changes on two subsequent paper mill runs gave close to the standard of our original sample. To our surprise fabrication of this product through the rest of the process showed that for the finished goods the material from our first factory test was really the most desirable. To establish this point, re-runs and minor adjustments were necessary. The swing into regular production followed.



Courtesy of The Hercules Powder Co.

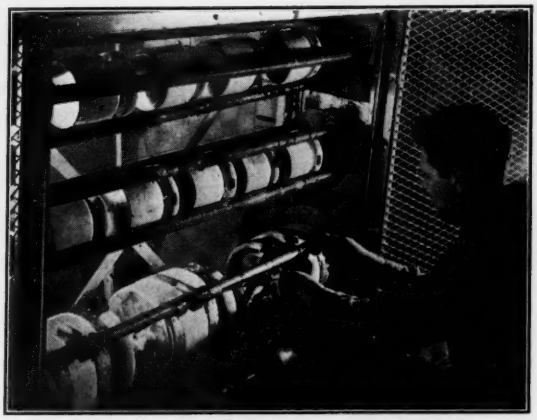
MULLER FOR CORE SAND, FOUNDRY LABORATORY, HERCULES EXPERIMENTAL STATION, WILMINGTON, DELAWARE

Though each job has new angles, requires different treatment, and presents unpredicted difficulties, the general pattern might be given as follows: (1) statement of the problem, (2) laboratory work, (3) development work.

The problem statement is a vital part of a job because it is in this that the highly generalized demand of the sales department or factory management, as the case may be, is crystallized into a form suitable for the technical worker. To say the water resistance of our plastic should be improved is not sufficient. Such a problem necessitates a review of service conditions and a consideration of the chemical and physical make-up of the plastic, in order to determine the material's weak point responsible for failure under service. For example, the problem of water resistance may be reduced to terms of means of blocking the water-reactive groups in the polymer. This preliminary work is usually covered by conferences and rapid library search. Most inventors have a somewhat justified impatience with the verbosity of men who have laid out beautiful intellectual patterns of the various technical fields, yet have not transmuted them into practical working inventions. To the impatient, energetic inventor the patterns of technical literature are just labyrinths of intricacies and non-essential side issues—the heart of the problem is his concern. The shortest distance, the straight line to development and production is his goal even if he must commit scientific heresies and perform unorthodox experiments. The inventor does not differ much from the successful archeologist who frequently digs in what authorities regard as barren ground.

After defining the problem in technical terms, the laboratory work is outlined according to factory practicality, speed of accomplishment, and sound fundamental basis. The plan of attack here does not resemble that on pure research where every point is meticulously carried out, but is more in the nature of field orders to keep the laboratory activity in a channel of work most likely to yield quick, successful results.

Once the laboratory work is planned, the next step is to get to work and let the work do your thinking. Work intensively with plenty of overtime and watch intently how your material responds. In a laboratory with a good plan and a goal, it is possible in a short time to put your material through a repertoire of hundreds of tricks—small chemical variations, temperature change, roll adjustment, and the like. Under such a rigorous third degree, your material will eventually crack and you see in it or its modifications the property needed in your invention. I remember one case, where the presence of tape-making rolls in the laboratory tempted us to try our goods through them, though the problem was obviously enough not a roll job. The test failed, but rumination on it suggested the key idea to break the problem. I had the thrill the next day of suddenly comprehending its significance. In a few minutes, with

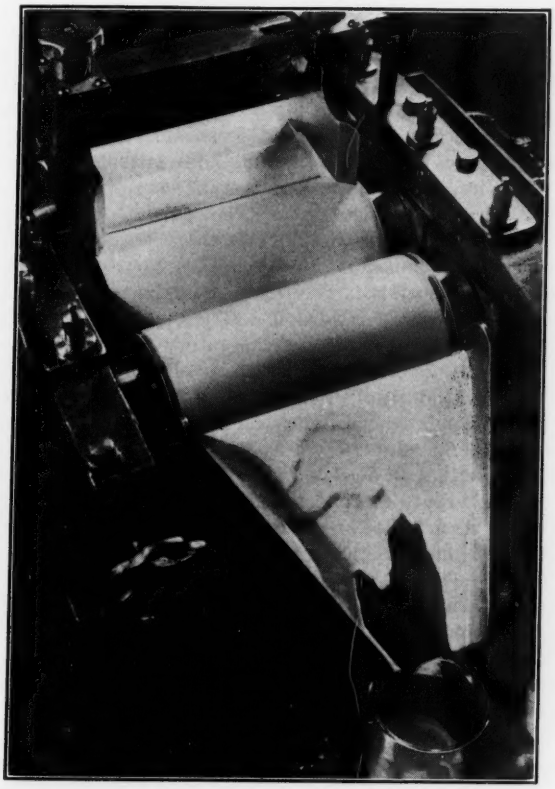


Courtesy of The Hercules Powder Co.

BALL MILL TRAIN FOR GRINDING EXPERIMENTAL LACQUERS

these same rolls and some metal strips, I made my first sample of the new plastic fabrication desired.

In the working out of an invention too much cannot be said of the value of intensive work and selective observation. It is obvious that such problems can be solved by slow, systematic research. Nevertheless, time and industrial budgets are limited and the inventor should, if possible, avoid the more detailed and rational method of the research worker. The intensive attack by trial and error method is well keyed to the industrial



Courtesy of The Hercules Powder Co.

EXPERIMENTAL THREE ROLL MILL FOR PAINT GRINDING

mood, and the worker in his desperation to break the impasse of his problem in a hurry will perform laboratory feats he didn't realize possible and will not take time to rationalize his failures. Selective observation of the response of his material under the constant hammering of his work is vital. The paramount question is, does the material have the characteristics which will give the desired results? If not, how much must it be changed? That is only answered when the material is observed under the conditions which the original plan laid down as necessary to assure a practical factory process. If after a few weeks of intensive effort on one plan the problem fails to open up it is dropped or shelved for research method attack and another plan is drafted and wrangled in the laboratory.

After the laboratory work has shaped itself into a practical answer, development can start. This usually begins with a survey of existing plant machinery to determine its adaptability for large-scale tests. If satisfactory equipment is found, the necessary mechanical gadgets are connected to it for the test of the new material. If not, the junk pile is raided and pilot plants built out of old compressors, old rolls, and what-have-you. The goal of this first stage of development is to get out a sample big enough to wave in front of the executives. It is easy to lose sight of the fact that until such samples made on large-scale machines are dramatically thrown down on conference tables the job is not done. To executives, even of modern enlightenment, test-tube samples and two-inch squares of new materials just do not seem more than laboratory curiosities. A written report may be an adequate termination of work in other fields, but in development I prefer to let large-run samples tell the final story.

With the development approved, there follows the detailed procedure of coating the process and laying out the mechanical requirements. The machinery is built, and then begins the suspense and irritation while, among endless adjustments and breaking in of crews, the new process gets under way. It may take months and years to knock the last kinks out of the process, but the development group's function is to stick to it until the process is completely ready for the production department. The weak point of most development is that it stops just short of a finished job and the production department carrying over work habits and prejudices of the old process show little enthusiasm for finishing it—so when anything goes wrong they condemn the new process and return to the old one.

Looking over this strenuous game of invention and development it appears quite unsatisfactory, compared to a well-modulated scholastic career. The only thing that can be said in favor of its chaos of nerve-wracking crises and transient periods of elation is that out of it industries are born, that in it, as we take it day by day, there is a texture of fascinating irony, such as in life itself.

[Mr. Miller describes the qualifications of the inventor as follows.]

In the matter of prerequisites for invention and development work, the characteristics required of a man entering this field are stamina, imagination, and background; stamina to "bull-doze" the job through its critical periods when things go haywire and the project would die of weariness if there wasn't a fighter somewhere pushing it; imagination to see the new way to do the job, to look past the practical man and theoretical man and their objections; background so you can raise your own objections, so you can temper your new way to fit the industrial world.

In the matter of background, scholastically a Ch.E. degree should give a sound theoretical foundation for such work; industrially, an apprenticeship in some in-

dustry entered upon in the old-fashioned spirit, learning from the old workmen; in addition, of course, extensive reading on the chemical problems that have been solved—and how.

XIII. THE RAILWAY WATER CHEMIST

R. C. BARDWELL

Robert C. Bardwell has been Superintendent of Water Supply for the Chesapeake and Ohio Railway Company since 1922. For the twelve years prior to that time he was with the Missouri Pacific Railroad Company. His office now supervises the water treatment program for the Chesapeake and Ohio, Nickel Plate and Pere Marquette railroads. This service covers 6927 miles of territory and supplies water for 1431 locomotives as well as for other purposes.

Mr. Bardwell received his academic training at the University of Illinois, specializing in Chemical Engineering. He is a member of Phi Lambda Upsilon, the American Chemical Society, the American Institute of Chemical Engineers, American Railway Engineering Association, American Water Works Association, and the Railway Bridge and Building Association.

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There are two fields for chemical work in railroad service. First, and probably the largest, is the testing department laboratory where materials are analyzed and tested to determine if they meet the purchase specifications. The work here is similar to that in large commercial general testing laboratories. The other is the water department laboratory which handles the control of water purification and miscellaneous tests in connection therewith.

These two fields are separate and distinct and require chemists with entirely different qualifications. In the testing laboratory, the work is all inside, running such time-consuming tests as are necessary for the examination of steels, metals, paints, oils, etc. Time is not the first essential and can be sacrificed for accuracy and attention to detail. The work of the water chemist, on the other hand, is an operating proposition. Conditions on one day are relegated to history on the next. The prompt and proper application of chemical knowledge is necessary to meet the conditions and keep them right on each day. The work is necessarily spread over a large territory which requires intimate familiarity with the individual equipment and local conditions. Knowledge of steam boilers and locomotive operation must be acquired. An understanding of human nature and the ability to place the proper value on the service to be expected is a decided asset.

The actual work begins in the water department laboratory. Here the regular water samples from the various points are examined and tested. Usually short routine tests are used, but occasionally complete mineral analyses are required, all of which methods are outlined in the last edition of "Standard Methods for the Examination of Water and Sewerage" as published jointly by the American Public Health Association and the American Water Works Association. All industrial laboratories have their own methods for routine tests which have been developed to take care of local conditions with sufficient accuracy to permit proper control. These short-cut methods are seldom taught or given much consideration in scholastic courses, as their accuracy depends largely upon a fundamental understanding of local conditions. The chemist beginning work in such an industrial laboratory must develop a thorough understanding of these short-cut methods and the meaning of their limits of accuracy, as the successful application of such methods is based on just such an understanding.

The actual motions and procedure in carrying out the tests are routine matters in the way they are handled. If the chemist does not have the vision to look behind the tests and perpetually question and picture what produces the results as indicated, the work is drudgery, and such a chemist has no place in this field. However, if the chemist views each test with the query as to what conditions produced such results, either chemical, mechanical, engineering, or personal, a wide kaleidoscope of interest is continually unfolding.

The major portion of water-testing work is volumetric analysis. The making-up and checking of standard solutions and indicators require careful application and understanding, as accuracy here is a prime prerequisite. The water-treatment chemicals, lime, soda ash, salt, sodium aluminate, coppers, and alum must be checked regularly for strength and purity. Complete analyses of scale samples are made occasionally. Oil used in water-service equipment is sometimes checked. Bacteriological examinations are made by only a few railroad laboratories, but an understanding of such work is an asset.

The greater portion of the time of the railroad water chemist is spent on the road where he must rely for results on solutions and equipment carried in a small testing case. Railroad water stations are located at isolated points in the alkali plains or maybe in the mountains of West Virginia or Pennsylvania, as well as at large city terminals which are more accessible. These plants must be visited and the conditions checked on the

ground, especially when the regular samples sent to the main laboratory indicate possible trouble. An understanding of engineering, mechanics, and hydraulics is an asset in making these inspections and a knowledge of chemistry is essential.

The railway water chemist is usually held responsible for the proper operation of the water in the locomotive boilers. Any conditions causing leaks must be corrected promptly. Scale deposition is to be avoided. These troubles can be readily eliminated by proper water treatment controlled by suitable chemical tests. Close coöperation with the boiler-maker forces is advisable in this work. Foaming troubles cause loss of power and delays to trains. The water chemist is required to follow up locomotive operation in various districts, making concentration pick-up tests in order to recommend a blow-off schedule which will keep the concentration below the critical foaming point. Close coöperation with the road foreman of engines and the operating officials is necessary in this work. The making of these concentration pick-up tests usually involves riding engines for several days with but very little opportunity for sleep, especially where the locomotives are used over more than one district, so that such work cannot be properly handled except by persons in good physical condition. This type of work requires the ability to get along well and work with fellow-employees.

The writing of reports and the proper keeping of files and records is a necessary adjunct to the duties of a railroad water chemist. As the work and locations are widely distributed, a certain amount of correspondence is involved. As a general rule, the officials to whom reports are made are not technically-trained men. For this reason, the descriptions and explanations must be deftly worded in order that the facts may be readily understood.

[In concluding his article Mr. Bardwell comments on the desirable personal traits of one engaged in this work, and surveys the field and prospects.]

The personal traits which are directly applicable to making a success in this work are honesty, initiative, resourcefulness, and diligence, all backed by plain common sense. Without honesty, both in purpose and intent, the confidence of superiors and co-workers cannot be retained and, without this confidence, consistent results are impossible. As much of the work is carried out at some distance from headquarters, the railroad water chemist must be capable of using initiative and assuming responsibility. Resourcefulness is necessary in making the best out of bad situations which are occasionally encountered. Laziness is a bad trait in any activity.

In considering any line of work, it is always well to survey the field and prospects. Railroad water chemistry cannot be said to be a rapidly expanding branch of the profession, although there has been a noticeable increase in the number of men engaged in this work during the past twenty years. In 1935, records indicate that there are approximately one hundred positions of this character in the United States. The starting salaries are not high, and advancement is seldom rapid. The promotions may lead to the position of Superintendent of Water Service, or the possibility of branching out into other departments of railroad, or industrial service, as the contacts made are many and sometimes valuable. In the end, advancement will depend upon the individual and his ability to take advantage of the opportunities as they arise.

The USES *of* EXAMINATIONS*

B. CLIFFORD HENDRICKS

University of Nebraska, Lincoln, Nebraska

AND

F. P. FRUTCHEY†

The Ohio State University, Columbus, Ohio

THE test as a service tool[1] with the emphasis upon its convenience for such use has been presented on a previous occasion. What follows is prompted by a desire to emphasize other functions of testing than merely its use as a means of rating students for course marks. The authors in the present instance will limit the "uses" to those of practical interest to the teacher, rather than to the administrator.

Professor Morrison is credited[2] with the statement, "Teachers should spend half their time studying their pupils as growing individuals and the rest of the time doing what that study indicates is desirable and necessary." There are three significant phrases in

* Presented before the Division of Chemical Education at the ninety-second meeting of the A. C. S., Pittsburgh, Pennsylvania, September 11, 1936.

† Present address: U. S. Department of Agriculture, Washington, D. C.

[1] HENDRICKS, B. C. AND O. M. SMITH, "Service tests for chemistry," *Sch. Sci. & Math.*, **35**, 488–91 (May, 1935).

[2] WOOD, B. D., "The major strategy of guidance," *Educational Record*, **15**, 11 (Oct., 1934).

that statement: "studying pupils," "growing individuals," and "doing what."

There are, of course, many ways of studying pupils. When we have them in large numbers a convenient mass-method of studying them is by testing them. We give them intelligence tests to gage the nimbleness of their wits. We give them placement tests to secure advance insight into their aptitudes and vocational promise. We give them achievement tests to uncover residues of information which have escaped the forgetting process. Then, when we seat them in our classrooms, we proceed by the ancient, but still modern, oral method of getting acquainted with them.

Dr. Morrison, however, did not contemplate a study of the pupil with a view to *passing* him or giving him a *grade*. That was quite incidental in his plan. And that brings a protest from many of our veteran teachers. In fact, the complaint is similar to the one which is lodged against the Coöperative Tests in Chemistry. "But the new tests have no passing grade! How, then, can they serve as the basis for promotion and graduation and honors and the rest?" These criticisms very pointedly raise the question, why do we give examinations anyway? The answer, one answer, repeated, *in order to study the pupil.*

A student is a "growing" pupil. That means he is changing. We, as teachers, are at times optimistic enough to think we may have something to do with that growth. Anyway, we'd like to be sure that there is growth, and one of our much used tools for testing for school progress is the examination.

Before going further, however, may we as teachers of chemistry consider just what growth we are expecting in our students. Is it the acquisition of a veritable encyclopedia of factual information? Is it such skill that they may face pages of hieroglyphics called symbols, formulas, and equations without a tremor of the nerves or the haunting fear that there may be one there that has not been mastered? Or does our catalog of items of growth include, also, an acquaintance with and an ability to use the rules, or principles, of the science? An understanding and a fluency of expression of the terminology of chemistry? A daily advance in the art of interpreting factual data gathered from either laboratory or library? A recognition of and an ability to use the laboratory as a court of appeal for testing postulated generalizations? Do we find an increased confidence in our pupil as a growing individual when we learn that his breakage account is less the second semester than the first? Or that he has developed some manipulative skills in our laboratory?

If we are to look for all these symptoms of growth it is too much to expect one instrument to make the revelation. Health would include no less than proper temperature, smooth lung action, and normal blood pressure. But we know that in testing for the first the thermometer is used; for the second the stethoscope; and for the third still a different indicator. Just so in seeking indices of progress in these various aspects of chemical growth, a test specifically built for that purpose must be used. This is said advisedly, for careful investigation has repeatedly shown that a student's success in remembering does not correlate well with the reduction of his breakage account or his skill in interpreting experimental data. It should be said then that in *using* tests *use* them to test for *that* for which they were constructed.

There are some attainments, sought by some teachers in their "growing pupils," for which there are no practical tests available. Of course, the essay test for such aims is always a possibility, but it is rather impractical because of the excessive time required for the student to take it, especially if it has enough requirements in it to sample adequately the field of the objective. Some such as yet unmeasured objectives for chemistry are: accuracy of observation; ability to organize factual material into logical relationships; ability to formulate and execute experimental procedures for testing tentative generalizations; and manipulative skills essential in laboratory practice. Here are uses for which there are, at present, no practical tests.

Of the three phrases previously abstracted from the Morrison statement, the most significant, so far as pupil growth is concerned, is "doing what that study indicates." One of the authors gives a placement test to a new group of first-year college chemistry students the first time he meets them. That placement test contains units which test for: ability to read, ability to interpret experimental data, ability to follow directions, ability to keep still (not answer) when he doesn't know, and ability to compute. What's the *use* of such a test?

In the first place, upon the outcome of that test the students are segregated into three groups: A, the slow students; C, the more successful students; and B, the intermediate group which last group usually includes about sixty or seventy per cent. of the class. That test (study) has indicated that some of these students are going to work more efficiently and be more successful than others. This segregation is "doing what that study indicates."

In the second place that "study" has indicated that some of those students are going to have to learn to read, learn to multiply, and learn to divide, in short, to learn a number of simple skills which, somehow, their high schools failed to teach them. In this act the curriculum for the course is modified. The use of this test has modified the subject matter and the method of teaching the course. How much modification is made is conditioned by further study of the pupil. This, needless to say, is accomplished largely by his oral response in class, his reactions toward the chemical aspect of his laboratory work, supplemented by written tests varying in time demand from fifteen minutes to one hour. But please note that in all this there are examinations in *use* even though they may be quite informal. And again it should be emphasized that, if it is reading the student should be taught, the

examination for evidences of growth is a test in reading, or if it is some phase of arithmetic which the student has to re-learn, the test should be for that skill.

If from time to time, say, every four weeks, a composite test is given containing units for a number of aims, the conscientious teacher is not satisfied by the net score on that test, but is anxious to get its diagnostic implications for each student. The word "implications" was used because in a test of only one hour's duration it is not possible to get a reliable index of a student's progress in any one objective for the course. But assuming there are five or six objectives the teacher is consciously seeking to develop at any one point in the course, it is possible to get some evidence of progress on each, even though that evidence is not based upon an adequate sample at any one time. Further, these bits of evidence, inadequate though they may be, may be cumulative so that during the full time of a semester they may become a valid basis upon which to conclude concerning any one student's mastery of that objective.

In synthesizing such an examination, then, the teacher brings together one unit on terminology, another on symbolism, another on application of principles, still another on drawing conclusions from experimental or other data, and perhaps a fifth on organization of some factual material into a logical outline. It is a distinct advantage if the teacher knows in advance the probable success of freshmen students with each unit so incorporated into this examination. Many experienced teachers, through the years, have accumulated such information on questions which they have used, and they have so many such questions that there is no hazard in using them over again. Just here is a service which the Coöperative Test Service could perform for teachers, *i. e.*, compile norms not only on Test Parts I, II, and C as wholes, but make available norms upon each unit within the test. If such individual requirements were placed, each upon five by eight cards, together with an index of the distribution of the responses to each requirement from one hundred or more freshman college students, a set of such cards might be comparable in value for a teacher who has the responsibility of preparing examination questions, to that of a Beilstein for a research worker. If the Coöperative Test Service is not interested in such a service, each teacher, by a bit of extra labor, may prepare his own deposit of such "knowns" for examination construction.

From correspondence received and conversation with teachers much skepticism has been expressed concerning the adaptability of the tests the Coöperative Test Service is producing, to local conditions and local emphasis of subject matter. Doubtless, there never will be a test that exactly fits any one institution's curriculum for first-year chemistry. But why should that especially worry a teacher? What one textbook ever fitted any one curriculum of a first-year course? Or what one laboratory lay-out ever has been accepted *in toto* by any one institution? An examination is no more sacred than a textbook. We have learned to leave out part of the adopted text and to rearrange the parts which we have chosen to use and to supplement by lecture or library assignments where the text has been deficient. Just so with parts of published tests. One of the authors used Part C of the 1936 Coöperative Chemistry Test as a part of his final examination. Time did not permit the use of the test as a whole, so all requirements having to do with the first semester's subject matter were deleted. The students understood and the results on the parts not deleted proved satisfactory for the examination. There were, even after the deletion of some test items, other items which the course had not touched in its presentation. At the time nothing was said to the students about them. It was quite noticeable, as one rated the papers, that almost without exception the students left those requirements alone. The instructors were pleased because they had sought to impress upon their students throughout the course the importance of a reasonable certainty of one's information. In other words, here in this examination was evidence that the students recognized that there were some things that they *knew* that they did not know. In fact, isn't the call for a student to make that sort of a decision in an examination evidence of the progress of the student toward that which most scientists desire in their students? Why, then, should any teacher become wildly excited over the presence in an examination of a test item on vitamins when his course "did not get that far?"

One further comment relative to the tests of the Coöperative Test Service may be pertinent. The purpose for which teachers in practice try out these tests is not primarily that the technicians may use their student responses for establishing norms. The primary purpose in using such tests undoubtedly should be that the teacher may secure dependable evidence upon which to guide the growth of the individual student. If the technicians can use the papers after the teachers are through with them, and, as a by-product, establish norms for the various parts of the test, that, of course, is good, but not primary. With that principle in mind many teachers would feel a greater freedom to adapt the tests to their own needs and by so doing make them a much more serviceable tool of teaching.

A use which is but little recognized for examinations in chemistry, judging from copies of actual test questions received from teachers of college chemistry, is that of making a comprehensive survey of the year's course. Probably the reason for the little attention given to this type of test is that it is inconvenient. Faculties are much given to discussions of survey courses and integration courses in different fields. In line with that trend of thought a modest beginning might be made in the field of first-year college chemistry by using the last month or six weeks of the year in an effort to integrate different phases of the course into

each other and by giving such a re-survey coherence by means of a comprehensive examination. It is to be expected that the authors would suggest Coöperative Test Service examinations for a trial for such a purpose. The subject matter in these examinations is chosen from the whole year's spread. The number of items in each part are adequate to give it the desired reliability, and most of its forms have been checked against the accepted essay response to make certain of their validity for measuring that objective.

Another use which, so far as the authors know, has not been made of these tests is that of *pre-testing*. The physicists[3] have made such use of their tests and consider them very valuable for that purpose. In other words, they use the test to aid placement, as well as estimate student progress toward mastery of that subject's objectives. In such use of the chemistry tests it would be desirable to warn the student frankly that many of the items in the test would be new to him, but that, notwithstanding, he should answer all that he possibly could of those that were familiar. There is a question in the minds of the authors as to whether there is enough familiar subject-matter in the tests in their present form to give any sort of an index of individual differences, particularly for students with no previous college or high-school chemistry. The fact that physics teachers have found their tests valuable for such purposes, however, should encourage chemistry teachers to experiment with that use. To follow such a pre-test by a similar test form as an achievement test would require that comparable forms of each test should be available for such purposes. That, of course, is a project for the test technicians to work through.

There are a number of uses for examinations which are commonly put forth by their proponents, such as: they stimulate student study, they help the teacher to locate weaknesses, etc., which have not been mentioned. Anyone sufficiently interested to secure Max McConn's "Examinations Old and New: Their Uses and Abuses"* will readily understand why there is uncertainty as to the importance of such uses. However that may be, it is the intent in this paper to stress those uses of the examination which aid a study of the pupil, that serve as a means of tracing growth, and that suggest such modification of content and method of instruction as most effectively provide optimum conditions of growth for the individual student. While examinations may be used with students in the mass, their greatest use is only possible when the examiner recognizes that use in terms of the individual.

[3] "The 1934–1935 College Physics Testing Program," *The American Physics Teacher*, **3**, 151–3 (Sept., 1935).

* This article is available for distribution in reprint form by the Coöperative Test Service, 437 West 59th Street, New York City.

BIOCHEMISTRY OFFERED IN COLLEGES OTHER THAN UNIVERSITIES AND MEDICAL SCHOOLS—A CORRECTION

Through an omission the names of Connecticut Wesleyan University and Connecticut College for Women did not appear in this article [J. CHEM. EDUC., **14**, 527 (1937)] in the list of undergraduate colleges which have endowments of $2,000,000 or more and which offer courses in biochemistry.

THE 1938 COÖPERATIVE CHEMISTRY TEST

The 1938 form of the Coöperative Chemistry Test will be available May 1, 1938. The test this year is divided into six sections, namely: information, vocabulary, problems, equations, application of principles, and interpretation of experimental data. Some questions in qualitative analysis are included.

In equations the students are required to give the product of the reaction, and balance, and to supply the formulas. Interpretation of experimental data, added for the first time, is designed to measure the student's ability to draw conclusions, to generalize, and to recognize the limitation of data. A set of data is given, and from this conclusions are drawn, or statements are made, as is commonly done by students. The examinee is required to indicate that the conclusion or statement given is correct, incorrect, or probable, or that the data are insufficient.

The test has been pre-administered to a sufficient number of students to demonstrate that the questions are of the desired difficulty, are valid, and that the time limitations are just. The questions in each section are arranged in order of their difficulty and equitably weighted. The test is so arranged that it may be administered in one period of ninety minutes or two periods of forty-five minutes. Separate scoring sheets for manual or machine scoring are available if desired. The time of scoring may be materially shortened by their use.

Thirty leading chemistry teachers read and criticized the test. It was re-written to meet their comments. Some statements of chemistry teachers about the test are as follows. "The 1938 form is a big improvement over last year's test." "On the whole the test is very thorough and representative of a year's work in general chemistry, including qualitative analysis, that is usually given." "The problems are a keen contribution to testing methods in chemistry." "The questions are thoughtfully designed to test the student's ability to use and to understand chemical information, rather than a task of memory."

The price is $5.00 per hundred or more, and orders should be sent to the Coöperative Test Service, 15 Amsterdam Avenue, New York. Manuals, scoring sheets, and report forms will be furnished with each order so that results may be used in the National Sophomore Testing Program. The Committee wishes that all the teachers would use these tests as part of their final examination and thus obtain the benefit to be derived from participation in this project.—*Committee on Examinations and Tests*, O. M. SMITH, *Chairman*

A SUBMERGED ELECTRODE APPARATUS *for* SPECTROSCOPIC ANALYSIS*

FLOYD TODD

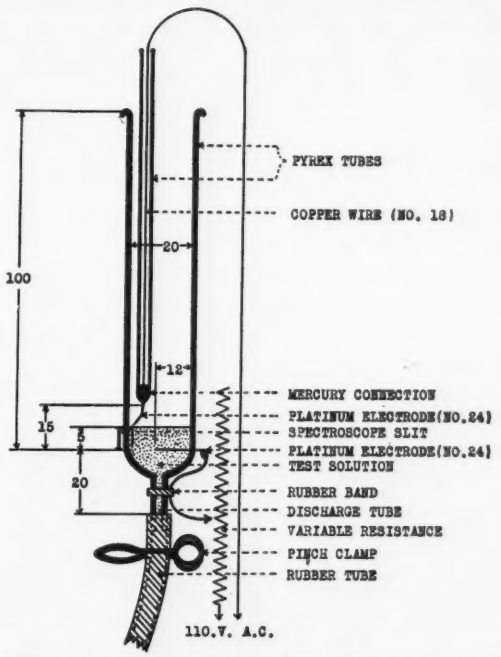
Ithaca, New York

AFTER making a rather comprehensive study of the various pieces of spectroscopic equipment, a new simplified device and method have been developed for making rapid visual qualitative spectroscopic analyses. Although it does not surpass the usual qualitative spectroscopic method, its simplicity and efficiency seems to the author to warrant its publication. It was considered inadvisable to use this apparatus for the infra-red and ultra-violet regions, since its radiations are comparatively weaker than those produced by the usual carbon arc apparatus.

The nature of the radiation which occurs on only one of the submerged electrodes is neither that of a spark nor an arc but appears as a characteristic homogeneous glow which confines itself to the immediate proximity of the electrode. This unusual property is due to the low voltage and low frequency alternating current which is used instead of the more common high voltage and high frequency alternating current required for the spectroscopic analysis of solutions.

The submerged electrode apparatus is diagrammatically illustrated in the accompanying figure. Small deviations from the dimensions given will have practically no effect on the operating efficiency of the apparatus. Since only the upper platinum electrode is worn away after about fifteen to eighteen hours of continuous use, it is easily replaced. This electrode is connected to the 110-volt A.C. line by means of a copper wire passing down to the upper platinum electrode and contacted to it by means of a small amount of mercury. The glow on the electrode can be shifted to the upper or to the lower electrode at will, depending on which electrode has the less surface area exposed to the liquid. It is not convenient to replace the lower platinum electrode. Therefore, it is desirable to make the glow appear on the upper electrode simply by adjusting its height so that it extends only four to six mm. below the surface of the liquid. The upper glow electrode is bent in order that it may be placed about one mm. from the wall of the tube. This is to give the spectroscope maximum illumination. The lower electrode is sealed in horizontally and is connected to a flexible copper wire by means of silver solder. This connection is fastened to the lower neck of the tube to protect the lower electrode from being broken out of the glass.

Operation of the submerged electrode apparatus is carried out by clamping the tube and upper glow electrode in a vertical position about one mm. in front of the spectroscope slit. The lower electrode is connected



SUBMERGED ELECTRODE APPARATUS, DIMENSIONS IN MILLIMETERS

in series with a variable resistance which is capable of dissipating 500 to 750 watts. (A Clarostat resistance with carbon discs has been used with quite satisfactory results.)

In making an analysis the liquid is placed in the tube as shown, and the resistance is gradually eliminated. In doing so, the liquid apparently begins to boil, and finally there is a minor explosion in the tube. This is due to an accumulation of oxyhydrogen in the tube which explodes when the upper electrode begins to

* The work on this submerged electrode apparatus was begun at the Philadelphia College of Pharmacy and Science and completed at Cornell University.

glow. This explosion is harmless, and for this reason *no stopper is used on the tube.* When the resistance is completely eliminated and there is a full 110-volt drop between the electrodes, the solution being analyzed boils slowly. The walls of the tube act as an air condenser. If, during an analysis, the liquid boils away too much, the loss may be replaced by adding distilled water.

Analytical Procedure.—Since all the analyses are preferably carried out in about ten per cent. nitric acid solution, it is first necessary to record all the hydrogen lines produced by the acid. The hydrogen lines may be used as reference lines. Of course, when once the positions of these hydrogen lines have been ascertained, it is not necessary to repeat it for any subsequent analysis. The platinum electrodes do not give any lines of their own in this apparatus.

In making an analysis of an unknown substance, 0.5 to 0.005 gram sample of the material is pulverized and then added to about three cc. of ten per cent. nitric acid. The mixture with the precipitate (if any) is analyzed in the submerged electrode apparatus. All of the lines are recorded. The hydrogen lines are checked. The remaining recorded lines are used for analysis. The best three persistent lines in the visual region of each element have been given in the included table. If two or, preferably, three of the lines of an unknown sample coincide with the same two or three reference lines of an element as given in the table, one may be certain that that element is present in the unknown sample.

PERSISTENT LINES

Element	*Wave length in Ångstrom units*			*Limitation of detection mg./cc.*
Ag	5465	5209	—	0.03
Au	4793	—	—	0.2
Ba	6141	6497	4934	0.07
Be	4572	4960	—	0.8
Bi	5209	4722	5134	0.9
Ca	4228	5602	5480–5410	0.02
Cd	5086	4800	4678	0.2
Ce	5189	5079	4737	1.0
Co	5353	5343	5266	1.0
Cr	4290	4274	4254	0.2
Cu	5782	5153	5105	0.1
Fe	4957	4891	4383	0.5
Hg	5790	5769	4358	0.4
In	4511	4101	—	0.03
K	4046	7682	6925	5.0
La	5183	4900	4430	2.0
Li	6708	6104	4603	0.04
Mg	5184	5173	4481	0.005
Mn	4823	4783	4763	0.07
Na	5893	5685	6157	0.009
Nd	5192	5120	5095	1.2
Ni	5082	4715	4401	1.0
Pb	4058	5609	4386	0.7
Pd	5542	5295	5163	0.2
Pr	4225	5110	4142	2.5
Sn	6453	5799	5563	0.2
Sr	4607	4215	4078	0.02
Th	5435	5068	4740–4607	3.0
Tl	5350	—	—	0.1
Zn	4810	4722	4680	0.06
Zr	4739	4710	4688	0.5

After the analysis the liquid may be recovered or discarded by pinching the clamp. The tube is flushed several times with water. Some metals become embedded in the upper platinum electrode and must be removed before making another analysis. This is done by placing about three cc. of ten per cent. nitric acid in the tube and making the upper electrode glow as before until all the lines disappear except those of the hydrogen. This treatment may require three to five minutes.

The limit of detection of each element in the pure state dissolved in ten per cent. nitric acid is also given in the table. When the elements are present in mixtures the limit of detection for any one element is not quite as remote as that given in the table.

The alkali metals and alkaline earth metals appear very prominent in the submerged electrode apparatus. The presence of relatively large quantities of these metals obscures the lines from nearly all the other metals. If, after making the first analysis, a large amount of the alkali metals appears to be present, these metals may be removed by taking advantage of the fact that the hydroxides of most of these interfering metals are water-soluble. Concentrated ammonium hydroxide is added to the acid mixture until it is decidedly alkaline. All the insoluble material is filtered off through a small Büchner funnel and washed thoroughly with water. The filtrate is discarded. The ammonium hydroxide forms some complex amine salts of cobalt, silver, and copper, and are consequently made water-soluble. Therefore, these metals and the alkali metals must be tested for before adding the ammonium hydroxide. The precipitate is redissolved in about three cc. of ten per cent. nitric acid and analyzed again.

Advantages and Scope of the Submerged Electrode Apparatus.—(*a*) This device may be used not only for true solutions but also for solids in suspension.

(*b*) The only accessory apparatus required is the small Clarostat resistance which operates on the ordinary 110-volt, 60-cycle alternating current.

(*c*) The thirty-one elements as given in the table give satisfactory lines for visual qualitative analyses. Several of the rarer elements also give good lines by this method. The elements Al, As, B, C, Cs, Mo, P, Rb, S, Sb, Se, Si, Ti, Te, U, V, and W do not give any suitable lines with this submerged electrode apparatus.

(*d*) This apparatus may be operated for long periods of time without any adjustment.

(*e*) The elements of the unknown material may be completely recovered after the analysis.

(*f*) A complete analysis of an unknown containing any of the elements listed in the foregoing table can be made in five to thirty minutes, depending on the complexity of the mixture.

"*and* LIGHT *the* GAS ISSUING *from the* JET"

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THE title of this article refers to a step in the usual hydrogen experiment in the elementary chemistry course. Students, as a rule, are still expected to burn the gas as it comes from the generator, and rightly so, inasmuch as that is probably the most outstanding property of the gas. They can see it burn, but sometimes they are forcibly impressed by the speed of its oxidation, *viz.*, when the air has not all been expelled from the generator.

Scanning the hydrogen experiments in the popular manuals brings to light a few statements which may be interpreted as illustrating a peculiar type of humor. In

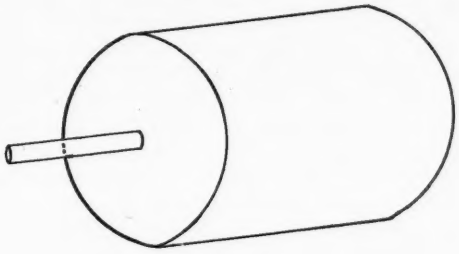

FIGURE 1

one we find that students are to "cautiously ignite" the hydrogen escaping from the jet. In another manual we read that all connections should be "very tight" in hydrogen experiments. Why? Why "very tight"? Merely snug-fitting stoppers will prevent the gas from leaking in this experiment and also function as a pressure safety valve. The procedure in a different manual instructs the students to produce the gas "for a minute or so" before heating the copper oxide in the experiment on reduction. When we consider the wide latitude in student interpretations of far more definite statements we may seriously question the wisdom of a "minute or so." The rate of hydrogen evolution varies so widely because of different acid concentrations, zinc surface area, catalysis, etc., that we have noted with pleasure that in the last revision of the manual of our adoption the item calling for the ignition of the hydrogen has been omitted.

To eliminate the danger to the students and the nerve-racking suspense of the instructor during the period of these experiments we have used with considerable success the following modifications in the apparatus. It is a change in the usual scheme for preparing any combustible gas in the elementary course which, as far as the author could determine, completely removes the hazards of those experiments. The explosions because of

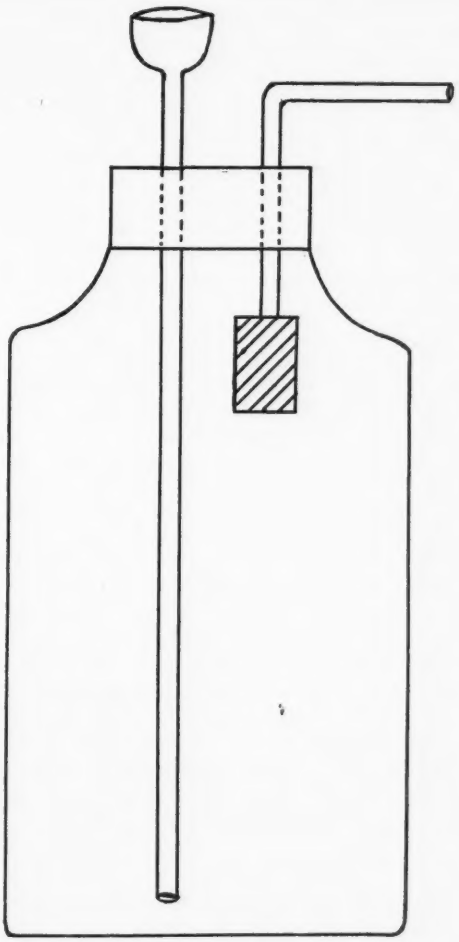

FIGURE 2

residual air in the apparatus are entirely eliminated by the use of a small porous aërator stone.* The aërator stone is inserted in the generator on the delivery tube.

* Manufactured by the Carborundum Company.

It is a device with which it is impossible to cause an explosion of any mixtures of gases in the generator, whereas, with the same apparatus lacking the aërator stone explosions occurred regularly. The stone functions as a flame arrestor in a manner analogous to a Davy lamp, the principle of which was used by Lebowitz[1] in making a protective device for gas generators. The stones, commonly used for aquaria aëration, are made of fused crystalline alumina in various shapes. The cylinder type, 1″ × 7/8″, with attached nipple, (Figure 1) has been used in this laboratory with excellent results. Both of these stones easily enter the gas-

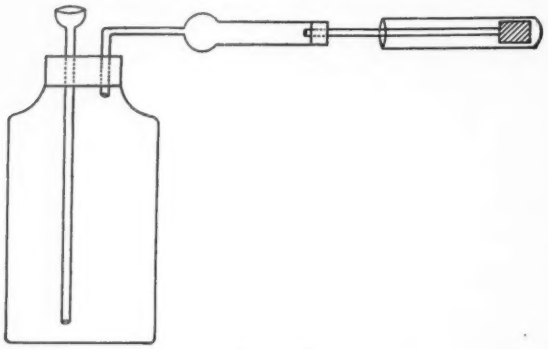

FIGURE 3

bottle generator and have functioned so efficiently that explosions would not take place in the generator through all ranges of explosive mixtures.

To test the efficiency of the stones as flame arrestors conclusively the apparatus was set up in the usual manner for making the gas except that a stone was placed in the generator on the delivery tube (Figure 2) and a Bunsen-burner flame at the exit end of the delivery tube. The system was, of course, filled with air. Zinc, diluted acid, and the catalyst were added. A stream of air, mixtures of air and hydrogen, and finally hydrogen were caused to impinge on the flame of the burner. There were a few small hydrogen barks resulting from the combustion of the mixtures in the delivery tube. Shortly afterward the hydrogen was ignited and continued to burn in the usual manner. The experiment was repeated many times, substituting different aërator stones, and in all instances satisfactory results were obtained.

[1] LEBOWITZ, S. H. "Protective device for gas generators," J. CHEM. EDUC., **11**, 311 (1934).

In order to further test the flame-arresting quality of the stones the author filled a large rubber balloon with two parts of hydrogen and one of oxygen. This mixture was ignited as it passed through an aërator stone. It continued to burn on the surface of the stone, the stone effectively preventing a flare-back into the large body of the mixture.

The device is readily adapted to another rather hazardous experiment, *viz.*, the reduction of copper oxide by hydrogen. If the gas is not dried the test-tube containing the copper oxide is merely placed over the delivery tube in the customary manner, and heating the oxide may begin at any time. If, however, the hydrogen is dried the apparatus is arranged as in Figure 3. This arrangement eliminates the possibility of a comparatively large amount of the explosive mixture collecting in the drying tube.

We have also found the device to be of value in the experiment on the Marsh test for arsenic. We feel that this latter step is of particular advantage in those laboratories which are not equipped with hoods, and because it increases the sensitivity of the test. Many instructors are fond of describing the minuteness of the amounts of arsenic which may be detected by decomposing arsine as produced in the hydrogen generator. However, when the experiment is performed by students considerably greater quantities of arsenic are required. When large laboratories are not equipped with hoods an appreciable amount of arsine may be permitted to escape into the atmosphere before all the air is removed from the generators. Inasmuch as the stones permit the delivery tube of a hydrogen generator to be heated at the beginning of an experiment it is possible to add an arsenic compound to the generator, heat the delivery tube, and thus prevent the liberation of the poison gas in the air of the laboratory.

CONGO RED. A SYNTHESIS ADAPTED TO SECOND-SEMESTER ORGANIC CHEMISTRY COURSES—A CORRECTION

As a result of an omission an error occurred in this article [J. CHEM. EDUC., **15**, 129–31 (Mar., 1938)]. On page 130 the tenth sentence in the first paragraph should read as follows. "The lower, presumably acid, layer is tested with water and, if soluble, discarded. The upper layer is washed in the separatory funnel successively, with water, sodium carbonate, and again with water."

There are two distinct classes of men: first, those who work at enlarging the boundaries of knowledge, and, secondly, those who apply that knowledge to useful ends.—PROFESSOR R. W. VON BUNSEN

RECENT BOOKS

THE TRI-SERVICE MANUAL OF LABORATORY WORK IN ORGANIC CHEMISTRY. *Ed. F. Degering*, Ph.D., Purdue University, West Lafayette, Indiana. John S. Swift Co., Inc., Indianapolis, Indiana, 1937. Manual form, ring binder, planographed, v + 97 pp., one side, perforated. 43 figs. 21 × 27.5 cm. $2.00.

The purpose of the book is to offer the student "(1) a set of experiments in which an approach has been made toward the use of semi-micro procedures, (2) a duplicate note-book system, and (3) self-measuring objective tests."

The manual represents a unique adventure in the treatment of organic laboratory work, and the author has gone far in achieving the purpose of his book. Thirty-three semi-micro experiments covering the conventional classes of organic compounds, followed by an introduction to qualitative organic analysis, with forty-eight objective tests, make up the main content. Preceding these is an excellent discussion of laboratory records and reports. The directions for preparations are clear and modern, and are followed as a rule by an excellent selection of property tests.

The experiments include only those that have been perfected in the Purdue laboratory. Although there is a good choice, it is expected that more experiments will be added in the ultimate form, which will also contain more theoretical material.

A few criticisms: Under carbohydrates, there is no mention of phenylhydrazine. In the detection of the element nitrogen in organic compounds the employment of a fusion mixture of magnesium powder and potassium carbonate* appears to be an improvement over the conventional sodium method cited by the author. The use of Drierite would facilitate some of the drying operations. The duplicate notebook idea (involving use of carbon paper) is probably good, but one doubts the advisability of allowing but one page for recording the experimental data in each exercise. Five of the first six objective tests review basic material in inorganic chemistry which has some bearing on organic chemistry; one or two such tests would seem to be sufficient.

The author considers the manual as a preliminary draft to be completely revised with the aid of a board of assistant editors before publication. In its present form, however, the work certainly makes a real contribution to the field of undergraduate organic laboratory practice.

C. S. ADAMS
AUSTIN M. PATTERSON

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YELLOW SPRINGS, OHIO

VOLUMETRIC ANALYSIS. *A. J. Mee.* Chemical Publishing Company, New York City. 1937. vii + 223 pp. 13 figs. 14 × 22 cm. $3.50.

This book is avowedly written as a text for the (English) student to use in preparation for his College Examinations. After an introductory section dealing with apparatus, calibration, types of volumetric reactions, records, and calculations, there are detailed treatments of acidimetry-alkalimetry, permanganate, dichromate, ceric sulfate, titanous sulfate, iodimetry, bromate, and precipitation. These sections on laboratory work are followed by a list of over two hundred practical laboratory problems dealing with applications of volumetric analysis. "Hints" are given for the best method of attack. An appendix provides a description of an automatic buret and pipet, a short discussion of indicators and mixed indicators, and a list of reagents needed for the problems. A four-place logarithm table is given.

In general the treatment is quite elementary. Although each type of analysis is profusely illustrated with laboratory exercises, these exercises are given in "cookbook" style, with little explanation of the chemistry involved, the applicability of the process, the sources of interference, or the likelihood of error. The sections on theory are too brief, as are the stoichiometric calculations. The best feature of the book is the list of problems; these are not the stoichiometric type of problem common to American textbooks, but are practical laboratory problems designed to test the student's knowledge of analytical processes and his ability to apply these processes in actual practice. For example, a typical problem is: "A solid is an impure specimen of cuprous chloride. Make experiments with the standard potassium permanganate solution and solid ferric sulfate provided, with a view to discovering a method for estimating the purity of the specimen." If the student fails to discover a suitable method he finds in the "Hints" that cuprous chloride will reduce ferric sulfate.

Outside of the problems, which appear to be taken from past examinations, the book contributes little not found in the widely used American textbooks, and it is inferior to these texts in theory, stoichiometric calculations, explanations of analytical procedures and sources of error, and in training the student for practical industrial analytical work. Moreover this book cannot be used alone as a textbook, since it has no discussion of the analytical balance or of the operations involved in selection and preparation of samples for analysis.

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THE CARBON COMPOUNDS. C. W. Porter, Professor of Chemistry in the University of California. Ginn and Company, Boston, Massachusetts, 1938. viii + 495 pp. 15 × 23.5 cm. $4.00.

"This book constitutes an outline of an elementary course in organic chemistry. Its scope is limited to fundamental principles and general reactions."

The book is organized under three general divisions; aliphatic compounds, aromatic compounds, and general organic reactions. The aliphatic compounds are subdivided in turn into the chapters: Hydrocarbons, Alcohols, Alkyl Halides and Paraffin Polyhalides, Ethers, Aldehydes and Ketones, Monobasic Acids and Their Derivatives, Optical Isomerism, Polybasic Acids and Their Derivatives, Aliphatic Amines, Cyanides and Cyanates, The Carbohydrates, and Enzymes. In the aromatic division a chapter is devoted to each of the topics: Hydrocarbons, Hydrocarbon Derivatives, Aromatic Amines, Phenols, Alcohols and Aldehydes and Ketones, Aromatic Acids and Their Derivatives, Orientation and Steric Influences of Substituents, Free Radicals, Dyes, The Proteins, Vitamins, Purines and Pyrimidines, The Alkaloids, and the Essential Oils. The last division of the book contains chapters on Hydrolysis, Oxidation, Reduction, Conjugation and Resonance, Condensation Processes, Structural Rearrangements, Appendix, Questions and Problems, and the Index.

The use of over twenty tables of physical constants tends to correlate to some extent the relation between structure and physical properties. A limited amount of space is devoted to mathematical developments. Graphical formulas are used wherever the clarity of the topic might demand more than constitutional formulas.

The text is sufficiently well organized and the pages adequately broken by equations which are interspersed with the reading material, so that a packed appearance is avoided.

The author gives first consideration to the chemistry of the various homologous series and then illustrates the series by giving detailed consideration to some of the more important members of the group. Nomenclature is stressed, although perhaps not adequately. The "ine" ending for the alkynes has been carried

Ind. Eng. Chem., Anal. Ed., 29, 135–6 (1937).

over from previous editions in lieu of the more acceptable spelling "yne."

The third division of the book, in particular, will appeal to *students* of chemistry. The book represents, in the opinion of the reviewer, an improvement over the previous edition which is in keeping with the progress of the science involved.

ED. F. DEGERING

PURDUE UNIVERSITY
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A TEXTBOOK OF QUALITATIVE CHEMICAL ANALYSIS. *Arthur I. Vogel*, D.Sc. (Lond.), D.I.C., F.I.C., Head of Chemistry Department, Woolwich Polytechnic: lately Beit Scientific Research Fellow of the Imperial College. Longmans, Green and Co., London, New York, Toronto, 1937. xi + 383 pp. 14 figs. 14 × 22 cm. $3.00.

This volume was written to provide a textbook at moderate cost which could be used by the student in English schools throughout the whole study of the subject, from School Certificate to Final Bachelor of Science Examinations of the Universities, as well as for independent laboratory guidance. The material of the book is organized as follows:

Chapter I. Theoretical Basis of Qualitative Analysis, ninety-eight pages.

Chapter II. Analytical Operations, fourteen pages.

Chapter III. Reactions of the Metal Ions (including tables for analysis of the analytical groups), seventy-four pages.

Chapter IV. Reactions of the Acid Radicals (with special procedures suggested for common interferences in the tests for acid radicals), seventy-five pages.

Chapter V. Systematic Qualitative Analysis of Inorganic Substances, fifty-seven pages.

Chapter VI. Modification of the Systematic Analysis when Organic Acids, Silicates, Borates, Fluorides, and Phosphates are present, thirteen pages.

Chapter VII. Reactions of Some of the Rarer Elements, nineteen pages.

Appendix. Atomic Weights, Preparation of Reagents and of Test Solutions, Detailed Suggestions on the Course of Instruction, and Table of Logarithms, twenty-four pages.

The discussion of ionization, chemical equilibrium, balancing equations, and oxidation potential, with the usual sub-topics, is reasonably complete, combining the classic and modern points of view. In the sections covering reactions of metals the usual inorganic reactions are supplemented by inclusion of the more important organic reagents. A fairly large number of acid radicals are covered in Chapter IV, including, for example, cyanide, cyanate, thiocyanate, ferrocyanide, ferricyanide, and the following organic acids: formic, acetic, oxalic, tartaric, citric, salicylic, benzoic, and succinic. In the section on systematic qualitative analysis, considerable stress is laid on preliminary tests by both dry and wet methods before attempting the usual dissolving of solids and analysis of the solutions.

The analytical procedures are described with distinctly less detail than we are accustomed to in the United States. This may well be due to the difference in method of teaching the subject in England and in this country. Apparently in England there is less of formal class work than here, the student being thrown on his own in the laboratory after a few introductory lectures. To prevent the laboratory work from becoming a mere routine following of directions, the procedures are purposely left more or less in outline form, thus requiring individual initiative in devising the proper conditions for carrying out particular operations.

The book seems fairly free of errors though one may note an uncertainty as to the reaction of Sb_2S_5 with HCl. On page 140 the equation is given correctly showing the formation of $SbCl_3$, S, and H_2S; on page 145 the main product is given as "$SbCl_3$ (or $SbCl_5$)", and on page 290 the products are given as "$SbCl_3$ (and/or $H_3[SbCl_8]$)". Also, on page 146, the last equation showing the formation of $Fe(NO_3)_2$ and N_2O by the reaction of HNO_3 on Fe is not in accord with the statement in the previous paragraph that a ferric salt is produced. Further, if As_2S_5 is boiled for ten minutes with 10 cc. of concentrated HCl, as recommended on page 145 in the analysis of the arsenic group, an appreciable amount of As_2S_5 will dissolve.

The author's practice of enclosing certain of the complex radicals in brackets—K $[Ag(CN)_2]$, page 34—of setting off the organic acid radicals from the replaceable hydrogen or metallic radical by a dot—$H{\cdot}C_2H_3O_2$, page 15—and of enclosing the ammonium radical in parentheses in certain compounds—$Mg(NH_4)PO_4$, page 25—represents an individual point of view which is not always adhered to in all parts of the book.

The selection of simpler topics for an introductory course is well done, while ample material is left to make a later course much more than a repetition of the earlier one. On the whole the author seems to have accomplished his purpose of writing a book that shall serve the student effectively over a period of years.

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LEHRBUCH DER CHEMIE. Zweiter Teil, Organische Chemie. (Textbook of Chemistry. Part II, Organic Chemistry.) *Walter Hückel*, Professor, University and Technical High School, Breslau. Akademische Verlagsgesellschaft m. b. H., Leipsig, Germany, 1937. xvi + 602 pp. 32 figs. 23 × 15.5 cm.

This text, the companion of an earlier one by the same author entitled "Part I, Inorganic Chemistry" is a thorough, interesting treatment of the field of organic chemistry. The book begins with a concise yet adequate discussion of the early development of the science and a brief description of various laboratory methods. The text was written for students beginning the study of organic chemistry, and is an excellent comprehensive survey of the field of such students. The author possesses the happy faculty of presenting his subject matter in a most interesting manner, and the reader's interest is increased in no small measure by the short biographical sketches which appear as footnotes throughout the book whenever the name of an important personage is mentioned.

A few of the references are to notes in Part I, so that for the most efficient use of the book Part I should be available. The number of such references is not large, however, and Part II could be used even without Part I.

The last chapter (thirty-two pages) dealing with carotinoids, vitamins, and hormones is exceptionally well done and should prove very useful to medical students. As a further aid to such students, the sections of particular interest to them are marked in the table of contents with an asterisk.

After a rather careful reading of the text, we are quite convinced that it is one of the best in its field that we have had the opportunity to examine. The book is interestingly written, it is authoritative, comprehensive, with no undue emphasis on any particular field, and remarkably free from typographical errors in structural formulas. In one detail, however, the structural formulas might be improved. No distinction is made in such structural formulas as that of azoxybenzene between the symbol for a coördinate covalence and that of an ordinary covalent double bond.

NATHAN L. DRAKE

UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

PRINCIPLES OF CHEMICAL ENGINEERING. *William H. Walker, Warren K. Lewis, William H. McAdams*, and *Edwin R. Gilliland*, Massachusetts Institute of Technology. Third edition. McGraw-Hill Book Co., Inc., New York City and London, 1937. ix + 749 pp. 15 × 23 cm. $5.50.

The Chemical Engineering "Bible" has appeared in its third edition. Col. William H. Walker, who was originally responsible for this book has died since the issue of the last edition, but his influence is still apparent in this new edition. The name of a new author, Edwin R. Gilliland, appears on the cover. The present

revision is largely the work of Professors McAdams and Gilliland.

The chapters on flow and fluids and flow of heat have been entirely rewritten to include the recent literature and explain more completely the phenomena involved. The authors should be particularly congratulated on the results they have achieved in these two most important chapters.

The chapter on filtration has been greatly improved. The equations and especially their interpretation have been changed and enlarged upon.

It is pleasant to note that the entire subject matter has been confined to the same page limitations as before even with the addition of considerable material.

The text has also been improved from a purely educational or explanatory standpoint, *i. e.*, the chapter on humidity and wet and dry bulb thermometers.

Irrespective of the importance of the influence of chemical reactions on problems concerning the design of chemical engineering equipment, texts on the principles of chemical engineering have been confined entirely to physical transformations. A problem such as the absorption of a gas by a liquid involving complex relations between concentrations of the chemical constituents in the two phases has received no serious attention. It is still hoped by many teachers of chemical engineering that such problems will eventually receive the consideration which they deserve.

This book by Walker, Lewis, McAdams, and Gilliland, PRINCIPLES OF CHEMICAL ENGINEERING, is unquestionably the best in the field, but we hope the time will come when the present subject matter covering physical operations will represent only half of the story. Chemical engineering is young, and it is quite evident that much must be done chemically before we will have a satisfactory quantitative basis for equipment design.

D. B. KEYES

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

INTERMEDIATE READINGS IN CHEMICAL AND TECHNICAL GERMAN. *John Theodore Fotos*, Associate Professor of Modern Languages, Purdue University and *R. Norris Shreve*, Professor of Chemical Engineering, Purdue University. John Wiley and Sons, Inc., New York City, 1938. xliii + 219 pp. 13.5 × 20.5 cm. $1.90.

According to the preface the purpose of this book is ". . . .to facilitate the study of German for chemists, chemical engineers, metallurgists, and pharmacists, and to serve as an introduction to the reading of chemical German from standard German reference books." The text is intended for use during the third semester of German and has been used successfully in mimeographed form at Purdue University for a number of years. All of the selections for reading have been taken verbatim from Ullmann's "Enzyklopädie der technischen Chemie" with the feeling that the interest of the student would be enhanced as he begins to realize the great value of German as an essential tool to assist him in the comprehension of data he will use in his professional work.

The book is divided into an introduction, the selections from Ullmann, and a vocabulary. "Reading difficulties of chemical and scientific German" make up twenty-eight pages of the introduction. A total of twenty-five subheads take up in excellent fashion, with examples, such difficulties as participial construction, word order, verbs, uses of *werden*, impersonal verbs, reflexive verbs, passive voice, prepositions, relative pronouns, suffixes, etc. This part should prove exceedingly helpful to the student, as most of his grammatical troubles are taken up in a comprehensive way and the whole arranged in a readily accessible fashion. A minimum vocabulary arranged in order of frequency of occurrence of each word in the book occupies eight pages of the introduction. The word frequency of each word is given, and an asterisk marks those of greatest importance in scientific German. The list is headed by *von* with a frequency of 319, and a total of seven hundred ninety-six words are included, each having a frequency of 3 or more. This list should prove useful to both the student and the instructor. If the instructor would assign only ten words a day, beginning with the top of this list, and then at the beginning of each class period read off each word and five review words a day and require each student to spell the words correctly, indicate gender, principal parts, first and second most important meanings, etc., the student should soon have a real working vocabulary of over five hundred words.

The selections from Ullmann make up one hundred fifty-three pages of the book but contain only about 2000 lines of text. A vocabulary of each new word on each page and notes on the text occupy the remainder of these one hundred fifty-three pages. These notes and vocabulary, together with the introduction, supply sufficient grammatical information to enable the student to understand the text thoroughly.

The complete vocabulary (including abbreviations) for the entire text is repeated alphabetically with word frequency from pages 155 to 214. Chemical symbols, German and English equivalents, and atomic weights of the elements occupy two and one-half pages, and two pages of strong and irregular verbs with their principal parts conclude the text.

The authors have done an excellent job of simplifying the translation with notes and making the vocabulary convenient for the student. It seems that they have almost overdone both. There appears to be little need for the teacher when the book has been made so complete and convenient in every respect. For classroom use I feel that the space of nearly one hundred pages that is devoted to vocabulary might well have been substantially reduced and students required to purchase Patterson's GERMAN-ENGLISH DICTIONARY FOR CHEMISTS for the year's work. Only the words not included in this dictionary need appear as a vocabulary and then only once at the back of the book. Many teachers will feel that there is some virtue in having to look up some words in a dictionary, as this effort will help to fix their meaning more firmly than a glance at their meaning on the same page. The reviewer thinks that too great a portion of the book is given over to vocabulary and not enough to text. While there is no direct statement that this book is intended to furnish the entire material for a three-hour one-semester course, such is implied. The reviewer's opinion is that students at this stage of their study of German should be able to read easily at least twice the approximately 2000 lines of relatively easy German such as is found in Ullmann. For class use few teachers will believe that the purchase of two or three books of this size and cost for each semester's work is warranted.

This book can serve an admirable purpose in making available a well-edited, well-manufactured, and well-annotated text for the student's acquiring a reading knowledge of German without the aid of a teacher. For such an objective this text makes the teacher unnecessary. There is a real need for books of this kind for this purpose. Many technical courses, such as chemical engineering, allow little, if any, time for acquiring a reading knowledge of German. Many other students can use material of this type profitably to acquire more confidence in their ability to read German. The reviewer believes that German is almost as important a tool for the chemist as mathematics.

Few errors were found in the text, but the use of English is sometimes involved, as in footnote 1, page 150: "erhitzt. How is a past participle used absolutely translated?"

ODEN E. SHEPPARD

MONTANA STATE COLLEGE
BOZEMAN, MONTANA

COLLATERAL READINGS IN INORGANIC CHEMISTRY. Edited by *L. A. Goldblatt*, University of Pittsburgh. D. Appleton-Century Company, New York, 1937. vii + 225 pp. 21.5 × 27.5 cm. $1.35.

This paper-covered volume fills a real, but perhaps unrecognized need in the teaching of general chemistry. Conscientious teachers have long felt the desirability of acquainting the elementary student with some of the original chemical literature. But library facilities are not always adequate, and it is often

difficult to pick out material suited to the student's need and capacity. This book contains thirty-one reprinted articles from eight different chemical journals, including several from the JOURNAL OF CHEMICAL EDUCATION. These articles deal with topics generally considered in elementary courses, from alchemy to the latest methods for the manufacture of phosphoric acid, chlorine, sulfuric acid, and ammonia. They are arranged in the approximate order in which they are likely to be considered, and interspersed with them are brief biographical sketches of twenty-three eminent chemists, past and contemporary. There is also a short biographical note for the author of each of the accompanying articles. The editor has written excellent introductory prefaces to a number of the articles, which contain helpful summaries and pertinent comment. The articles are well chosen, with regard to the balance between the historical, descriptive, theoretical, and practical, and although the collection contains about as much reading as the average student is likely to do in a year's time, many teachers will wish to supplement it by still further references. For this purpose, the report of the Committee on Chemical Libraries, which is reprinted as the last article in the book, will be of value. The inclusion of the July, 1937, Market Report will also be useful in giving the student an appreciation of the cash value of some of the chemical substances he uses. All in all, the student will find this book much more interesting reading than his textbook, and, at its moderate cost, he will probably be able to afford a copy of his own, rather than depending upon reference copies in the library. Finally, this brief introduction to the literature of chemistry may well inspire him to dig into it deeper and to discover other original sources fully as interesting as these.

N. W. RAKESTRAW

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LOW TEMPERATURE PHYSICS. *M.* and *B. Ruhemann*. Cambridge University Press, Cambridge, England, 1937. ix + 313 pp. 114 figs. 14 × 21.5 cm. $5.00.

This book will doubtless be received with especial interest at the present time because of the recent extension of the range of low temperatures accessible to experiment and the extremely interesting phenomena being discovered in this range. The authors were situated at the time of writing at Kharkov, U.S.S.R., where a low temperature laboratory has recently been established; before this they had worked with Simon in Germany and Oxford, and are amply qualified by first-hand experience for their task.

The purpose of the book is to give a comprehensive survey of the entire field of low temperature physics for the general physicist. In this general survey the authors discuss both the problems of experimental technic and those of theoretical interpretation and significance. The discussion of experimental technic is perhaps not sufficiently detailed so that the specialist could design low temperature apparatus on the basis of it without further study, but it is sufficiently detailed to suggest the nature of the experimental problems and difficulties and to give the reader an appreciation of the ingenuity which has frequently distinguished the solutions. An interesting feature is the historical discussion, which often displays a feeling for the human side of physical discovery which is not usual in the writings of physicists. This historical discussion brings out features which are not always properly appreciated, such as the wealth of qualitative knowledge attained by Olszewski. The theoretical discussion is not detailed enough to satisfy the physicist exclusively interested in theory, or to be used for purposes of instruction in theoretical physics, but is admirably done from the point of view of the general physicist who wants a clear survey of the nature of the ideas.

The order of presentation is from macroscopic to microscopic phenomena. Part I deals with historical matters, general descriptions of apparatus and theoretical considerations governing the production of low temperatures, and the experimental results dealing with phase equilibrium between vapor, liquid, and solid phases, including a discussion of rectification and the properties of binary mixtures which is not usually given. Part II deals with phenomena in crystals—crystal structures stable at low temperatures, molecular rotation, specific heats, and Nernst's law. Part III deals with phenomena involving spin—ortho- and para-hydrogen, paramagnetism, and magnetic phenomena in general, including magnetic cooling and the recent methods for reaching the lowest temperatures by this method. Part IV deals with phenomena involving the "free" electron—electrical and thermal conductivity and supraconductivity. The topics of supraconductivity and specific heats have perhaps not been treated with the fullness which their relative importance justifies, but this was done intentionally because they have been sufficiently treated in other places.

The preface is dated December, 1935. It is unfortunate that publication in a subject in which experimental progress is now so rapid has been so long delayed; the recent exciting work on the properties of helium II and new properties of supraconductors came too late for inclusion. There is, however, an addendum in which the more important new references up to May, 1937, are given.

P. W. BRIDGMAN

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THE RETARDATION OF CHEMICAL REACTIONS. *Kenneth C. Bailey*, Sc.D., Litt.D., F.I.C., Fellow of Trinity College, Dublin, Professor of Physical Chemistry in the University of Dublin. Longmans, Green & Co., New York City, Edward Arnold & Co., London, 1937. viii + 479 pp. 29 figs. 15 × 23 cm. $8.00.

Why should the chemist be interested in *retarding* chemical reactions? Isn't it difficult enough to promote them?

So natural a response to the title "Retardation of Chemical Reactions" will, however, suffer considerable change when one realizes the "..... loss, inconvenience, and even calamity suffered continually through the occurrence of undesired reactions, the oxidation of materials which are better unoxidized, the corrosion of metals, the ageing of rubber, the development of rancidity in fats, the deterioration of chemicals in the laboratory, the knocking of fuels in internal combustion engines, the explosion of fire damp in coal mines"—to mention but a few cases considered by the author where the retardation of chemical reaction becomes the chemist's paramount problem.

Despite its importance, no previous general treatment of this branch of kinetics has appeared. It therefore becomes doubly valuable to have under one cover a bibliography of 1630 original and source items dealing with retardation phenomena, together with a critical discussion of their contents. In many of these collected references, the material relevant to retardation hides under titles far removed from the central theme of this book and would be extremely difficult to locate through *Chemical Abstracts*.

The author has wisely excluded subjects which he felt himself insufficiently equipped to treat adequately or which would have expanded the text unreasonably; retardation by intensive drying, by poisoning of intentionally introduced catalysts, by salt effects and retardation of enzyme action have been eliminated from consideration.

The historical approach is followed for each topic, with less significant details relegated to small type. The advantages of such a chronological development are particularly evident in Chapters 3 to 6.

Of these, the first two contain a review of the "Oxidation of Phosphorus" and "Hydrogen-Oxygen" reactions published prior to the introduction of chain mechanisms. One is brought face to face with the confusion existing at that time.

The succeeding chapter contains the most compact, although inclusive, summary of the concepts and mathematical consequences of "Chain Reactions" yet published.

A re-examination of these same two oxidations ". . . . . in the Light of the Chain Theory" follows. Presented in this contrasting fashion, it is indeed a forceful argument for the chain theory

to see the previous confusion of inexplicable upper and lower explosion limits, inhibitor and surface effects, swept into a semblance of order.

Especially noteworthy is the critical review of the "Work of Moureu and Dufraisse" on auto-oxidation and anti-oxygen activity. The author favors an alternative theory of aldehyde oxidation, through chain reactions initiated (or inhibited) in the liquid-gas interfacial film. However, a sense of proportion is evident even in dealing with a personally favored theory—which cannot be said of several authors in the related field of homogeneous kinetics. Adverse theories are presented; the pet theory is not stretched.

Oxidation of sulfites, inks, and hydrocarbons, and stabilization of chloroform, ether, hydrogen peroxide, and perfumes are among the liquid phase reactions discussed. The author unfortunately overlooked the parallelism between acidity function and reaction rate (1932) in his chapter "Reactions Involving Sulfuric Acid."

No single theory fits these various reactions, resulting in a separate or "unit" treatment of each particular subject; the single common factor is "retardant effects." However, the logical development of *each* topic, profusely illustrated with summarized experimental results, should become a nucleus around which the teacher of chemistry can construct lectures on these rarely discussed yet important themes. For the research worker, this book cannot but act as a stimulus toward the solution of problems suggested by the excellent compilation of existant data.

JOSEPH GREENSPAN

BROOKLYN COLLEGE
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LE RAFFINAGE DES CORPS GRAS. *George Porchez*, Ingeneur I. N. A. Dunold, Paris, France, 1938. viii + 166 pp. 23 figs. 16.5 × 25 cm. Relié 78 Fr., Broché 58 Fr.

This book is a description and explanation of the fundamental principles of the refining of fatty substances with particular emphasis being placed on the preparation of edible oils and fats. The first chapter briefly describes the nature of fatty compounds and the extraction of the usable material. The second chapter gives the principal impurities in edible oils and fats and describes the methods of mechanical purification, filtration, and refining with sulfuric acid. The third chapter discusses neutralization by lye and the ways of recovering the neutral oil and eliminating the soap. The use of steam distillation and esterification as methods of removing the acids are treated briefly. In the fourth chapter the removal of mucilage and phosphatide is described, while the fifth chapter deals with decoloration. Chemical bleaching and removal of color by adsorbants is described. Five adsorbants are discussed and the methods for regeneration of them are mentioned. The sixth and last chapter explains the removal of odors by steam distillation and by vacuum distillation.

The treatment of all the material is descriptive and well organized. The book can be recommended for those wishing a brief survey of the processes for the preparation of edible oils.

ARTHUR A. VERNON

RHODE ISLAND STATE COLLEGE
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SYNTHETIC RESINS AND ALLIED PLASTICS. Edited by *R. S. Morrell*, in collaboration with *T. Hedley Barry*, *R. P. L. Britton*, and *H. M. Langton*. Oxford University Press, London, 1937. x + 417 pp. 14 × 22 cm. $11.00.

A comparison of this volume with its predecessor, NATURAL AND SYNTHETIC RESINS, published in 1926, reveals many improvements, reflecting the growth of the synthetic resin industry during the intervening ten years. In the earlier book, for example, sixty-nine pages were devoted to a discussion limited almost entirely to the phenol-formaldehyde, urea-formaldehyde, coumarone-indene, acrolein, and furfural resins and the ester gums. The present volume not only amplifies and brings up to date the treatment of these resins, but also devotes considerable space to new subject matter comprising the alkyds, and resins derived from petroleum, chlorinated hydrocarbons, aryl sulfonamides and formaldehyde, vinyl compounds, and acrylic acid and its derivatives. Its scope has, moreover, been broadened to include the important cellulose derivative and casein plastics, and, more briefly, some of the rubber derivatives and certain naturally occurring substances such as the bituminous materials. The chapter on causes of resinification has been expanded from eight pages in the old book to sixty-six pages in the present volume. The chapter on testing of synthetic resins has likewise grown from six to sixteen pages. These two chapters add much to the practical as well as to the scientific value of the book, and will be appreciated by all students and workers in resin chemistry. Additional new subject matter is to be found in the new volume in a comprehensive chapter on molding compositions and molding technic, and in three chapters dealing with the use of resins, varnishes, and plastics in the field of electrical insulation. The introductory chapter, classifying the more important synthetic resins and plastics and summarizing their physical and chemical properties and applications, is excellent. The book also contains several interesting and instructive charts and tables. A bibliography at the end of each chapter lists references to original sources of information, inviting and facilitating further investigation of any topic of particular interest.

While a single volume, designed by its authors, as this one is, as a compilation and critical summary of the published information on synthetic resins cannot be as detailed as the more comprehensive treatises which are available, a more detailed description of certain relatively recent applications of synthetic resins, such as in veneering and in plywood and safety glass manufacture, would be desirable. The book is impaired by occasional repetition, by frequent inaccuracies in equations and structural formulas, and by a number of typographical errors.

The book affords interesting reading to anyone who wishes to familiarize himself with synthetic resins, although a knowledge of organic chemistry is necessary for a proper understanding of it. It will be chiefly of interest, therefore, to the more advanced college student and to the resin chemist as a source of general information as well as a convenient reference book.

G. H. LATHAM

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HANDBUCH DER METALLPHYSIK. II. Die Heterogenen Gleichgewichte. *Rudolf Vogel*, University of Göttingen. Akademische Verlagsgesellschaft, Leipzig, 1937. xxiii + 737. 491 figs. 16 × 24 cm. Paper covered, RM. 66, bound RM. 68.

Professor Vogel has added another excellent monograph on the phase rule to the rather long list which has appeared before, beginning with Bancroft's Phase Rule (1897) and including volumes by Roozeboom and Schreinemakers, Tammann, Clibben, Findlay, Blasdale, and others. The general plan of the book is not unlike that of previous writers, beginning with one-component systems and ending with those of four components. It is much more elaborate in its presentation than, for instance, Findlay, which has become rather a standard work in this country, but it is much less of an encyclopedia of the subject than the great work begun by Roozeboom. Although writing primarily for those interested in metals, the author has wisely not limited himself to metallic systems.

Perhaps the chief difficulty which students find in studying the phase rule is with the diagrams which have been developed to represent the very great variety of possible changes in phases when a system containing more than one component is subjected to changes in pressure temperature and concentration. Such diagrams are a kind of short-hand, peculiar to the subject, and their meaning is by no means always self-evident. Moreover, a number of different ways may often be used, and are used, by different writers to represent the same facts. The author recognizes this difficulty very clearly and while he continually uses diagrams, some of which are exceedingly complicated, his explanations in

the text are clear and should go a long way to eliminate many difficulties which the subject presents.

The printing and the diagrams are excellent; but the paper is so weighted that the book is uncomfortably heavy to handle. The binding is so flimsy that it had already begun to break down when received by the reviewer.

H. W. FOOTE

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DIE CHEMIE DES PYRROLS. II Band. Pyrrolfarbstoffe. 1 Hälfte, Porphyrine, Hämin, Bilirubin und ihre Abkömmlinge. *Hans Fischer* and *Hans Orth*, University of München, Germany. Akademische Verlagsgesellschaft m. b. H., Leipzig, 1937. 764 pp. Paper covered, RM. 42, bound, RM. 44.

During the past years considerable progress has been made in the elucidation of the chemical structure of animal and plant pigments and in the preparation of certain of their degradation products and in the synthesis of various natural compounds. The senior author (Fischer), who, in collaboration with his various associates, has contributed a great deal to the solution of this intricate problem, has, in coöperation with Orth, undertaken to write a comprehensive review of the latest achievements in this field of biochemistry. Their book, which is written in several volumes, is more or less an encyclopedia on this subject. In this volume the authors have discussed in detail the chemistry of porphyrin, haemin, bilirubin and their derivatives and have described the preparation and properties of several hundred related derivatives of this group of compounds. Throughout this volume the authors have not failed to point out the chemical interrelationships between the different groups of compounds. The description of the chemical investigation has been wisely illustrated as much as possible by structural formulas which will make it easier for most readers to understand the reactions involved. There can be no doubt about the thoroughness with which the authors have compiled the great number of references which deal with this subject.

The book will be welcomed by those who are actually engaged in this field of research, as it gives them a convenient source of finding any desired information and reference concerning this subject of biochemistry. The book is too advanced and too detailed to be of great use and help to the student of chemistry and to the teacher of general college courses in chemistry.

HANS JENSEN

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CHEMISTRY, MATTER, AND LIFE. *Stephen Miall*, LL.D., B.Sc., and *Laurence Mackenzie Miall*, B.A. Longmans, Green and Company, New York; Edward Arnold and Company, London; published in London by Richard Clay and Sons, 1937. x + 296 pp. 12 × 18.5 cm. $2.60.

Much regarding the nature and purpose of this book can be inferred from the title, "Chemistry, Matter, and Life." The authors state in their opening sentence, "We are trying in this book to explain in the simplest possible language the nature of material things, the changes they undergo as the result of chemical action or the influence of light, the nature of the substances that exist in living plants and animals, and how these alter in the ordinary course of their lives." The above statement together with some of the chapter headings which follow indicate that the book is a treatise for the "intelligent layman," which runs the gamut of inanimate matter and gives some introduction to the behavior of animate matter. Some of the twenty-seven chapter titles which may be mentioned are as follows: Early Pioneers, The Chemists' Signs and Symbols, Family Groups, Electricity and Chemistry, Crystals and Arrangement of Atoms in Space, Different Varieties of the Same Substance, How Light Affects Matter, X-Rays, Elements that Emit Rays, What is an Atom?, Chemical Attraction, Breaking up the Atom, Electron Diffraction, Living Things, The Vitamins, How Plants Grow, The Colors of Leaves and Flowers, and Inheritance.

In the first few chapters of the book something of a chronological order of presentation is used, which makes the material easy to follow. However, this order is not maintained throughout the book, and each chapter is something of a unit in itself. This arrangement is a fortunate thing and makes the book a far more useful one for reference and supplementary reading than it might otherwise be. However, one might wish to reverse the order of some of the chapters in the book. In particular might be mentioned the one on "How Light Affects Matter," which deals with the emission of light by atoms and the spectra of elements and gives a somewhat detailed discussion of the spectrum of hydrogen in which is included the mathematical formulas for the Lyman, Balmer, Paschen, and Brackett series of lines which precedes by three chapters the one on "What is an Atom?" which gives the modern interpretation of the energy levels of the atom and the distribution of electrons in these levels, etc. Or, one might feel that the "layman" could follow the relatively simple chapter on combustion earlier in the discussion than he could understand the one on electron diffraction which precedes the former by several chapters. But one must remember that it is impossible to choose a wholly satisfactory order of presenting material and that things are very much as the proverbial Irishman said, "Any subject would be easier to learn if one could know something about it before starting to study it." At any point in the discussion of a subject some knowledge—and often a good deal of knowledge—must be presupposed. And although this book is written in about as elementary a fashion as possible it presupposes, in many places, a fair amount of knowledge of chemistry and physics, or at least these are necessary for a thorough enjoyment and understanding of the material. In writing this book the authors have undertaken and done well the most difficult thing to do. To write with scientific accuracy over a wide range of material for the layman is not an easy task.

Any really adverse criticism which the reviewer might wish to mention would be the kind that might be passed upon this sort of book in general. It is not a text and cannot be studied as such, but it is almost too brimful of well-chosen information—and some on highly technical subjects—for a book which, in places, reads nearly as easily as fiction. For the most part, the book reads easily enough for reading at a few sittings. One is tempted to run on without being conscious of the vast amount of material that he does not take time to digest. One who does not already know the subject well might find himself rather breathless without knowing exactly why. The book has the good and the bad qualities of one of the better books which treat so widely of the science of chemistry for the layman.

Perhaps the thing regarding this book that will be of most interest to the teacher is the fact that a chapter or two at a time can be used as supplementary reading. Students will find the book helpful and stimulating additional reading. The paper and the size of the print are not all that could be desired for such a book, but it is well illustrated with excellent photographic plates and diagrammatic drawings. Without very obviously trying to do so, the authors have succeeded well in leaving the reader with a very definite feeling of the universality of chemical phenomena and of the intricacies and beauty of the laws governing the behavior of matter. The book is worthy of a useful place in the school or college library as well as in the private library.

H. H. FILLINGER

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HOLLINS COLLEGE, VIRGINIA

NEW REINHOLD BOOKS

INDUSTRIAL CHEMISTRY

A New Third Edition (1937)

By Emil Raymond Riegel, Ph.D.

50 Chapters. Ill. 830 p.....$5.75

Expressly planned for those who wish to familiarize themselves with the changes that new processes and products are bringing about in established businesses. The author has been careful to arrange each chapter in logical sequence with sketches and drawings designed to illustrate modern development in the Industry. Tables, production figures and prices, all of recent date, serve to emphasize the economic importance of each group of manufacturers from the standpoint of yearly business. A special point has been to make the list of reading references as rich as the literature allowed, with emphasis on recent publications.

In preparing the third completely revised edition of this book Dr. Riegel has supplemented his own profound knowledge of the field by collaboration generously extended from industrial technologists, government officials and members of research organizations specially in touch with the subject matter of each chapter.

We have no hesitation in characterizing Dr. Riegel's present effort as the most complete, informative, accurate and readable survey of the whole field of chemical industry that has ever been offered to the English-speaking public.

PHOTOELEMENTS AND THEIR APPLICATIONS

Dr. Bruno Lange, translated by Ancel St. John, Ph.D. Illustrated. 304 pp. $5.50.

Dr. Lange, who is the inventor of one of the most widely utilized types of photoelectric equipment, and who has devoted a lifetime of study to the subject, has endeavored in this book to give a clear outline of the basic electric phenomena and the historical development of photoelements, and their physical properties and a detailed discussion of the many-sided possibilities of applying them for scientific and industrial purposes.

The use of these photoelectric cells for illumination meters, twilight switches, light barriers and the like, has been familiar to engineers for many years; but the introduction of talking motion pictures so greatly stimulated the interest in this class of equipment that from that time on they have invaded many other fields of application. In this transition from a laboratory device to an article of industry Dr. Lange has played a great part, and this book makes available to other workers in the field his profound knowledge and varied experience of the subject.

COLLOID SYSTEMS

A Survey of the Phenomena of Modern Colloid Physics and Chemistry

By Priv.-Doz. Dr. A. Von Buzágh, translated by O. B. Darbishire, B.Sc., edited by W. Clayton, D.Sc. Foreword to the translation by Prof. Dr. Wolfgang Ostwald. 332 pp. with illustrations and tables. $9.00.

"In the present work I have tried to give, as far as possible, an objective account of the leading principles of modern colloid science, and then to draw attention to the close relationship between physical chemistry and the study of colloids.

"I have not striven to attain completeness. Some knowledge has been assumed in the reader, and I have refrained from the introduction of details and the usual elucidation of elementary fundamentals. Occasionally, indeed, a departure from this plan was unavoidable. In the treatment of some phenomena and conceptions I have, even at the expense of due proportionality, found it necessary to go more closely into details. I have permitted myself this conscious departure from the plan of the work in the case of some of the simplest problems and fundamental conceptions, and this because it is precisely in these simple cases that misunderstandings and prejudices still exist, on the part of physical chemists as well as colloid chemists."—from the Author's Preface.

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TRADE ANNOUNCEMENTS

"Precision" Gas Burners for the Laboratory

A wide variety of burners for all types of laboratory work are described in an eight-page (21 × 27.5 cm.) catalog and price list recently issued by the *Precision Scientific Co., 1736–54 North Springfield Ave., Chicago, Ill.*

New Fostoria Buret Lamp

This model, #41-M, was developed specifically for use with laboratory burets, and features the well-known ball-and-socket construction pioneered in lighting equipment by Fostoria.

Two bell type reflectors illuminate the two tubes, light being supplied by a bayonet-type, double-contact 25-watt candelabra bulb in each reflector. The ball and socket joint on each side permits instant adjustment to the particular case. Overall size of $7\frac{1}{4}'' \times 8''$ makes the #41-M readily adaptable to the majority of burets.

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Safety Chart

A chart which specifies types of safety goggles to wear for protection against eye hazards in all principal industries has just been completed by the Safety Engineering division of *American Optical Company, Southbridge, Mass.* Upon request, it will be sent to any industrial concern without cost.

Probably the most concise and complete chart of its kind, it classifies eye-hazardous operations by industries and recommends specific types of eye-protection equipment which have been developed for each hazard.

The chart was designed to aid industry select the proper safety equipment needed in the fight to reduce the annual 200,000 industrial eye injuries.

Portable Cooling Unit for Constant Temperature Baths

A portable cooling unit for use in baths or tanks where bath temperature is to be maintained at or below room temperature with an accuracy of plus-minus 1 °C., is announced by the *American Instrument Co., Silver Spring, Md.* It is especially advantageous for warm-weather operation of constant-temperature baths.

The unit consists of a suitable refrigerator unit fitted with a cooling coil and expansion valve. The refrigerator is mounted in a perforated metal housing. The cooling coil is connected to the refrigerator by seamless flexible metal tubing. The expansion valve is automatic in operation and requires no attention.

The refrigerator measures only 12 × 15 × 21 inches, and, being mounted on ball-bearing casters, may be moved about easily.

This unit is put into service quickly, and no installation is required. Merely roll the cooling unit to the bath or tank whose contents are to be cooled, immerse the coil in the bath liquid, set the thermoregulator and place it in the bath, plug in to the current supply, throw the switch, and the unit is ready for continuous duty. No pipe connections to be made; no valves to operate; no adjustments to be made other than setting the thermoregulator; no boring of holes or breaking of pressure connections; no brine or water cooling system required.

The unit is fully described in manufacturers Bulletin 1055-CE which will be sent on request.

Water-Soluble Resin

A new water-soluble resin is announced by the *Glyco Products Co., Inc., New York*, under the name of Hydroresin A. This product is a light-brown viscous liquid with high adhesive properties and is very slow-drying. On the addition of water to Hydroresin A no decrease in viscosity or lack of clarity is noticed until the amount of water is about 70% of the weight of Hydroresin A. Increasing the amount of water gradually thins down the solution which becomes milky, but which can readily be cleared up by the addition of alkali. Hydroresin A is completely soluble in Alcohol and small percentages of Toluol can be added without affecting the clarity of the product. Hydroresin A blends with waxes, oils, rosin, shellac, latex, casein, glue, etc., forming compounds with many interesting properties.

Samples and further information can be obtained from the manufacturers, the *Glyco Products Co., Inc., 148 Lafayette St., New York City.*

Shriver Filter Presses

A new catalogue of Filter Presses and Diaphram Pumps is being distributed by *T. Shriver & Company, 837 Hamilton Street, Harrison, New Jersey.* The catalogue illustrates and describes numerous models and shows installations in various industries. It also contains suggestions for plant layouts, information about the operation, care, and maintenance of Filter Presses and Diaphram Pumps and other information that should be helpful in the selection and operation of filtration equipment. A copy of the catalogue may be had by writing the company.

The Luminograph

R. L. Van Name Company, 95 Madison Avenue, New York City, have recently published a folder describing the Luminograph. The Luminograph is a plate which becomes phosphorescent on short exposure to daylight or artificial light. It makes exact photographic reproductions of documents, illustrations, etc. Proper contact between the surface to be reproduced, photographic paper, and the Luminograph gives a photographic print which is developed by the common developing solutions in a few moments. No camera is necessary.

New Water Still Catalog

The Barnstead Still & Sterilizer Company have just published a new complete catalog of water-distilling equipment and accessories. Containing approximately seventy pages, this well-illustrated book gives the complete details of the construction and operation of all Barnstead Stills. Included are small laboratory stills, medium-sized stills for laboratory and industrial plants, large industrial type stills, "extra duty" stills for hard water service, and single, double, and triple stills for hospital use. In addition to the stills, storage tanks, mountings, automatic controls, and cut-offs are illustrated and described. Complete data tables containing sizes, weights, capacities, and other information are given on practically every piece of equipment in the book. Free copies may be had by writing to the *Barnstead Still & Sterilizer Company, 63 Lanesville Terrace, Forest Hills, Boston, Mass.*